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# JOURNAL OF PALEONTOLOGY

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*A Division of the American Association of Petroleum Geologists*

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# JOURNAL of PALEONTOLOGY

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# CRETACEOUS AND TERTIARY PELECYPODS OF THE PACIFIC SLOPE INCORRECTLY ASSIGNED TO THE FAMILY ARCIDAE

PHILIP W. REINHART
Tracy, California

ABSTRACT

A number of species of pelecypods from the Pacific Slope of North America, incorrectly described under the names of genera belonging to the Arcidae, are here catalogued and correctly allocated, so far as possible. "*Arca*" *tehamaensis* Stanton, "*A.*" *textrina* Stanton, and "*Barbatia*" *woodfordi* Hanna are here assigned to genera of the Parallelodontidae. "*Arca*" *darki* Dickerson is not an arcid; the family to which it belongs is undetermined. One new species, *Parallelodon* (*Nanonavis*) *whiteavesi*, is described.

A number of species of taxodont bivalves on the Pacific Slope of North America have in the past been described incorrectly under the generic names *Arca* and *Barbatia* of the family Arcidae. Although many of these species have been removed by later workers from this family and allocated to other groups, others still remain assigned to the Arcidae. It is the purpose of this paper to catalogue all of these originally incorrectly assigned species, including those that have later been correctly allocated, and to place them, insofar as possible, in their correct taxonomic groups, in order that the list of species of Arcidae from the Pacific Slope will no longer be encumbered with names that belong elsewhere. The genera that the writer includes in the family Arcidae have been discussed in a previous paper (1).

One new name is here introduced: *Parallelodon whiteavesi* Reinhart, n. sp. Photographs are included of the following species hitherto known only from drawings or from poor photographs: The two specimens of "*Barbatia*" *andersoni* upon which the original description of *Porterius* was based; the holotypes of "*Arca*" *vancouverensis* and of "*A.*" *biloba;* a topotype of "*Arca* (*Nemodon*)" *simillima;* a specimen of "*Grammatodon*" *carinatum* from the same locality as the specimen upon which the subgenus *Nanonavis* was founded; finally, the hinge and ligamental area of a topotype of "*Barbatia*" *gabbi* are illustrated for the first time.

*Acknowledgments.*—I wish to thank Dr. H. G. Schenck of Stanford University for reading and criticising the manuscript of this paper; and Drs. E. M. Kindle and F. H. McLearn of the Geological Survey of Canada for the loan of specimens from British Columbia. Other acknowledgments appear in the text.

The table does not include "*Arca* (*Cucullaea*)" *inornata* Meek and Hayden (2), the type species of the later-named *Grammatodon* Meek and Hayden, 1860. This species, originally described from the upper Jurassic of the Black Hills, Nebraska, has been reported from the California Cretaceous (3). The specimen upon

The disposition of the described species dealt with in this paper is shown in the following table:

| *Original name applied to species* | *Disposition of species in this paper* |
|---|---|
| CRETACEOUS SPECIES | |
| *Arca breweriana* Gabb, 1864 | *Parallelodon* (*Nanonavis*) *brewerianus* (Gabb) |
| *Arca* (*Nemodon*) *cumshewensis* Whiteaves, 1900 | *Parallelodon* (*Nanonavis*) *cumshewensis* (Whiteaves) |
| *Arca decurtata* Gabb, 1869 | Synonym of *Cucullaea* (*Cyphoxis*) *gravida* (Gabb) |
| *Arca* (*Cucullaea*) *equilateralis* Meek, 1864 | *Cucullaea? equilateralis* (Meek) |
| *Arca gravida* Gabb, 1864 | *Cucullaea* (*Cyphoxis*) *gravida* (Gabb) |
| *Arca* (*Nemodon*) *simillima* Whiteaves, 1900 | *Parallelodon* (*Gilbertwhitea*) *simillima* (Whiteaves) |
| *Arca tehamaensis* Stanton, 1895 | *Parallelodon* (*Gilbertwhitea?*) *tehamaensis* (Stanton) |
| *Arca textrina* Stanton, 1895 | *Nemodon? textrina* (Stanton) |
| *Arca vancouverensis* Meek, 1864 | *Parallelodon* (*Nanonavis*) *vancouverensis* (Meek) |
| EOCENE SPECIES | |
| *Arca biloba* Weaver, 1905 | Synonym of *Cucullaea mathewsonii* Gabb |
| *Arca clarki* Dickerson, 1917 | Not one of the Arcidae; generic position uncertain |
| *Arca columbiana* Weaver and Palmer, 1922 | Synonym of *Plagiocardium brewerii* (Gabb) |
| *Barbatia woodfordi* Hanna, 1927 | *Porterius woodfordi* (Hanna) |
| OLIGOCENE SPECIES | |
| *Barbatia andersoni* Van Winkle, 1918 | Synonym of *Porterius gabbi* (Dickerson) |
| *Barbatia gabbi* Dickerson, 1917 | *Porterius gabbi* (Dickerson) |

which the report is based is No. 832, Stanford University type collection of paleontology. This specimen is so poorly preserved as to make its specific and even its generic identification impossible.

Inasmuch as several of the Cretaceous species here dealt with belong to the genus *Parallelodon*, an artificial key has been prepared (see p. 171) as an aid in segregating these species into their proper subgenera. The type species of the subgenera recognized are as follows:

Genus *Parallelodon* Meek and Worthen, 1866.
Type species: "*Macrodon*" *rugosus* Buckman, 1845 (from the Bathonian, Jurassic, of Cheltenham, England).
Subgenus *Catella* Healey, 1908.
Type species: "*Grammatodon*" (*Catella laticlava* Healey, 1908 (from the Rhaetic, Triassic, of Upper Burma).
Subgenus *Beushausenia* Cossmann, 1897.
Type species: "*Cucullaea*" *hirsonensis* d'Archiac, 1843 (from the Inferior Oolite, Jurassic, of La Reinette, near Hirson, France).
Subgenus *Gilbertwhitea* Crickmay, 1930.
Type species: "*Arca* (*Nemodon*)" *simillima* Whiteaves, 1900 (from the Cretaceous of Queen Charlotte Islands, British Columbia).
Subgenus *Grammatodon* Meek and Hayden, 1860.
Type species: "*Arca* (*Cucullaea*)" *inornata* Meek and Hayden, 1858 (from the upper Jurassic of the Black Hills, Nebraska).
Subgenus *Nanonavis* Stewart, 1930.
Type species: "*Grammatodon*" *carinatum* (Sowerby) Woods, 1899 (from the Greensand, Cretaceous, of Blackdown, England).

Of the six subgenera here recognized, only two (*Nanonavis* and *Gilbertwhitea*) appear to be represented on the Pacific Slope. These are similar respectively to *Grammatodon* and *Beushausenia* but differ in that the anterior teeth of *Gil-*

*bertwhitea* and *Nanonavis* tend to be parallel to the hinge line as are the posterior teeth, whereas in *Grammatodon* and *Beushausenia* the anterior teeth are typically oblique to the hinge, as in *Parallelodon*, and not parallel to it. The relationship between *Gilbertwhitea* and *Beushausenia* is particularly close, but because of the distinction mentioned it is advisable to keep the two separate.

It is difficult to determine just how close the resemblance between *Nanonavis* and *Grammatodon* actually is, due to the poor preservation of known specimens of the type species of *Grammatodon*, *G. inornatum* (Meek and Hayden). These two seem superficially somewhat similar, but they differ in dentition, as pointed out above. Furthermore, on the type species of *Grammatodon*, radial ribs are absent, and only fine radial lines are known, although Arkell (4) figures several species of *Grammatodon*, on most of which radial ribs are present on part of the shell at least, showing a variability in *Grammatodon* in this respect. However one of the radially-ribbed species, which Arkell (5) included in *Grammatodon* is "*G.*" *carinatum* (Sowerby), the genotype of *Nanonavis*. Radial ribs are well developed on *Nanonavis*.

### *Artificial Key to* Parallelodon *and its Subgenera*

The following key is based, in part, upon the descriptions and illustrations of Arkell to which the reader is referred for further details.

A. Shell with a pronounced mesial sulcus, which extends from beak downward nearly to middle of ventral margin; on internal molds forms a sharp, conspicuous groove (7).
Dentition as in *Parallelodon s.s.*...*Catella*

AA. Shell without this pronounced sulcus.
B. Shell with byssal gape. Beaks subterminal (located near anterior end).
C. Posterior teeth nearly parallel to hinge line; anterior teeth oblique.
D. Elevated flange bordering posterior adductor muscle scar. Shell alate.....*Parallelodon s.s.*
DD. No elevated flange bordering posterior adductor muscle scar. Shell non-alate.....*Beushausenia*
CC. Both anterior and posterior teeth nearly parallel to hinge line.....*Gilbertwhitea*
BB. Shell without byssal gape. Beaks subcentral.
C. Anterior teeth oblique, nearly vertical to hinge line....*Grammatodon*
CC. Anterior teeth, though slightly oblique, nearly parallel to hinge line.....*Nanonavis*

## CRETACEOUS SPECIES

## Genus PARALLELODON Meek and Worthen, 1866

## Subgenus NANONAVIS Stewart, 1930

### PARALLELODON (NANONAVIS) VANCOUVERENSIS (Meek)

Plate 27, figure 4

*Arca vancouverensis* MEEK, *1864*, Albany Inst., Trans., vol. 4, art. 2, p. 40; Cretaceous of Vancouver Island, British Columbia.—WHITEAVES, *1903*, Canada Geol. Survey, Mesozoic fossils, vol. 1, pt. 5, p. 392.—MERRILL, *1905*, U. S. Nat. Mus., Bull. 53, pt. 1, p. 57; holotype in U. S. Nat. Museum.

Not "*Arca vancouverensis* Meek." ARNOLD, *1908*, U. S. Nat. Mus., Proc., vol. 34, pl. 31, fig. 6; *1909*, U. S. Geol. Survey, Bull. 396, p. 11.—ARNOLD and ANDERSON, *1910*, U. S. Geol. Survey, Bull. 398, p. 60. (=*Parallelodon brewerianus* (Gabb)).

*Grammatodon? vancouverensis* MEEK, *1876*, Geol. and Geog. Survey Territories, Bull., vol. 2, no. 4, pp. 356, 357, pl. 3, figs. 5, 5*a*.

*Grammatodon vancouverensis* Meek. WHITE, *1889*, U. S. Geol. Survey, Bull. 51, pt. 3, pp. 34, 39; Cretaceous of Sucia Island and Vancouver Island, British Columbia.

Not *Nemodon vancouverensis* (Meek). WHITEAVES, *1879*, Canada Geol. Survey, Mesozoic fossils, vol. 1, pt. 2, pp. 163, 164, pl. 19, figs. 1, 1*a* (=*Parallelodon whiteavesi* Reinhart, n. sp.).—DILLER and STANTON, *1894*, Geol. Soc. America, Bull., vol. 5, pp. 443–445.—ANDERSON, *1902*, California Acad. Sci., Proc., 3d ser., vol. 2, no. 1, p. 32 (=*Parallelodon brewerianus* (Gabb)).

Not *Nemodon vancouverensis*. STANTON, *1895*, U. S. Geol. Survey, Bull. 133, p. 18; Basal Horsetown, near Wilcox's ranch, Tehama County, California.

Type locality: Cretaceous of "Komooks" (present accepted spelling is "Comox," according to F. H. McLearn of the Canadian Geological Survey), Vancouver Island, British Columbia.

Type material: Holotype and paratype? U. S. Nat. Mus. 12398; two specimens; one a right valve on which the ornamentation is partly preserved and upon which the original description of the species was based; the other, a mold of a small left valve. Plastotypes, Stanford Univ. 6003 (holotype), 6004 (paratype?).

Although *Parallelodon vancouverensis* is closely related to *P. brewerianus*, the two species nevertheless differ slightly. On both species the anterior ribs are variable in size and more widely spaced than the others; but in *P. vancouverensis*, Meek states (1857) that "on the anterior end about every fourth one of the costae is larger than those between." This arrangement was also observed by me on a specimen from Sucia Islands, Washington. However, on topotypes of *P. brewerianus*, the ribs alternate in size so that every second rib is the larger. Whether or not this difference is of specific importance must remain questionable until more abundant specimens of *P. vancouverensis* are available.

In an effort to verify the occurrence of *P. vancouverensis* in basal Horsetown beds near Wilcox's ranch, Tehama County, California, reported by Stanton (1895, p. 18), I recently visited this locality. One mile east of the ranch house, at a horizon mapped by F. M. Anderson (9) as basal Horsetown, I collected a few specimens of *Parallelodon*, along with *Lytoceras batesi* and several other Horsetown species listed by Stanton (*loc. cit.*) from this same general locality. Although the *Parallelodon* is somewhat similar in form to *P. vancouverensis*, it nevertheless represents a distinct species, as yet undescribed, having much finer surface ornamentation than *vancouverensis* and lacking the enlarged anterior ribs present on that species. My collections to date, at this as well as at other localities in California, have failed to show the presence of *P. vancouverensis* or of *P. brewerianus* in rocks older than Chico.

### PARALLELODON (NANONAVIS) BREWERIANUS (Gabb)

*Arca breweriana* GABB, *1864*, California Geol. Survey, Paleontology, vol. 1, pp. 193, 194, pl. 25, fig. 181; Cretaceous of Cottonwood Creek (Shasta County) and Tuscan Springs (Tehama County), California.

*Parallelodon* (*Nanonavis*) *brewerianus* (Gabb). STEWART, *1930*, Acad. Nat. Sci. Philadelphia, Special pub. 3, pp. 69, 70, pl. 3, fig. 1; lectotype, from the Cretaceous of Cottonwood Creek (Shasta County), California. Complete synonymy given.

Type locality: Cretaceous of Cottonwood Creek (Shasta County), California.

Type material: Lectotype, Philadelphia Acad. Nat. Sci. 4440.

This species is so similar in general appearance and dentition to "*Grammatodon*" *carinatum* (Sowerby), the genotype of *Nanonavis* (pl. 27, figs. 6*a–c*), that Stewart's assignment of *Parallelodon brewerianus* to *Nanonavis* can hardly be questioned.

### PARALLELODON (NANONAVIS) WHITEAVESI Reinhart, n. sp.

*Nemodon vancouverensis* Meek. WHITEAVES, *1879*, Canada Geol. Survey, Mesozoic fossils, vol. 1, pt. 2, pp. 163, 164, pl. 19, figs. 1, 1*a*. (Not *Arca vancouverensis* Meek, 1864.)

Type locality: Cretaceous of Blunden Point, Vancouver Island, British Columbia. Collector, C. F. Newcombe.

Type material: Syntypes, Canada Geol. Survey, Ottawa, 5684 and 5684a. Plastotypes, Stanford Univ. 5280 and 5280a.

This species has been described and figured by Whiteaves (1879), who incorrectly referred it to "*Nemodon*" *vancouverensis*. *Parallelodon whiteavesi* is distinguished from *P. brewerianus* and from *P. vancouverensis* by its greater size, by its lack of a sharp ridge from umbo to

posterior ventral margin, and by a more rounded ventral margin. Judging from the plastotypes, Whiteaves' illustrations are accurately drawn, except for the fact that the hinge and ligamental area are somewhat crushed in the center on syntype 5684a, a condition that is not indicated by Whiteaves' fig. 1*a*.

Dimensions (in millimeters): Stanford Univ. plastotype 5280 (=Canada Geol. Survey 5684; Whiteaves, 1879, pl. 19, fig. 1), exterior left valve, length (incomplete) 67, height 50. Stanford Univ. plastotype 5280a (=Canada Geol. Survey 5684a; Whiteaves, 1879, pl. 19, fig. 1a), interior right valve, length (incomplete) 63, height 47.

Summary of distribution: In addition to its Cretaceous occurrence on Vancouver Island, specimens of this species are in the California Academy of Sciences collection from the following localities: California Acad. Sci., locality 1430, Upper Cretaceous, Johnson's ranch, 15 miles south of Rosario, Lower California. A list of species collected at this locality is given by F. M. Anderson and G. D. Hanna (8) who assign the beds at this locality to the Rosario formation. California Acad. Sci., locality 463, Panoche formation, Upper Cretaceous, near Oil City, Fresno County, California, "a few hundred feet" stratigraphically below the base of the Moreno shale. *Parapachydiscus catarinae* Anderson and Hanna is also present at both of these localities.

### PARALLELODON (NANONAVIS) CUMSHEWENSIS (Whiteaves)

*Grammatodon inornatus* Meek and Hayden. WHITEAVES, *1884*, Canada Geol. Survey, Mesozoic fossils, vol. 1, pt. 3, p. 235, pl. 31, figs. 8, 8*a*, *b*; Cretaceous of Queen Charlotte Islands, British Columbia. (Not *Grammatodon inornatus* (Meek and Hayden), 1858.)

*Arca* (*Nemodon*) *cumshewensis* WHITEAVES, *1900*, *op. cit.*, vol. 1, pt. 4, p. 294.

Type locality: Cretaceous of Cumshewa Inlet, Queen Charlotte Islands, British Columbia.

Type material: Types, Canada Geol. Survey, lectotype 4915, Cumshewa Inlet; paratypes 4914a–d, Skidegate Inlet. Plastotypes, Stanford Univ. 5281, Cumshewa Inlet; 5282–5285, Skidegate Inlet. All the specimens appear to be internal molds.

The lectotype, here chosen, is the specimen that was figured by Whiteaves (1884), pl. 1, fig. 8. It is the best-preserved specimen in the lot and the only one on which the dentition is at all preserved, judging from the casts, as well as from Whiteaves' description. It is a left valve, showing a few horizontally-placed teeth at the anterior and posterior ends of the hinge. In general shape these specimens suggest internal molds of *Parallelodon brewerianus*.

## SUBGENUS GILBERTWHITEA Crickmay, 1930

### PARALLELODON (GILBERTWHITEA) SIMILLIMA (Whiteaves)

Plate 27, figs 7*a*, *b*

*Nemodon fischeri* D'Orbigny. WHITEAVES, *1884*, Canada Geol. Survey, Mesozoic fossils, vol. 1, pt. 3, p. 234, pl. 31, fig. 5; Cretaceous of Maud Island, British Columbia. (Not *N. fischeri* D'Orbigny, 1850.)

*Arca* (*Nemodon*) *simillima* WHITEAVES, *1900*, *op. cit.*, pt. 4, p. 293.

*Gilbertwhitea simillima* (Whiteaves). CRICKMAY, *1930*, Univ. California, Dept. Geol. Sci., Bull., vol. 19, pl. 3, fig. *d*; diagram of dentition.

Type locality: Cretaceous, east end of Maud Island, Queen Charlotte Islands, British Columbia.

Type material: Holotype, Canada Geol. Survey 4913; hypotype, 8901.

*Parallelodon simillima* resembles *P. brewerianus* and *P. carinatum* in dentition. The resemblance to *P. carinatum* may be seen by comparing my plate 27, fig. 6*a*, with the diagram of the hinge of *P. simillima* given by Crickmay (1930, pl. 3, fig. d). *P. simillima*, however, differs from the other two by having a byssal gape and by lacking a sharp umbonal ridge such as is present on the others. The specimen of *P. simillima*

here figured (pl. 27, figs. 7*a*, *b*) has the following dimensions: length 41.8 mm., height 21.6 mm., convexity of both valves together estimated to be 20 mm. (shell is slightly crushed). The surface of both valves is covered with many fine, uniformly-spaced radial ribs, faintly beaded on the anterior part of the shell. Concentric growth lines are prominent. The hinge is not clearly exposed. The ligamental area of the left valve is partly preserved, having a maximum width of nearly 4 mm. opposite the beak. Nine ligamental grooves are present on the posterior part of the area; the anterior part is not well preserved. The beaks point forward slightly. A distinct mesial sulcus extends from the tip of the beak down to the ventral margin. This specimen is from the upper part of the Yakoun formation of Robber Point, east end of Maud Island, at or very near the type locality of the species.

PARALLELODON? (GILBERTWHITEA?) TEHAMAENSIS (Stanton)

*Arca tehamaensis* STANTON, *1895*, U. S. Geol. Survey, Bull. 133, pp. 18, 50, pl. 6, fig. 8; Shelton's Ranch (Tehama County), Calif. —MERRILL, *1905*, U. S. Nat. Mus., Bull. 53, pt. 1, p. 57; holotype in U. S. Nat. Museum.—GILLET, *1924* (*"kehamaensis"* by error), Soc. géol. France, Mém., vol. 1, no. 3, p. 14; generic allocation questioned.

Type locality: Shelton's Ranch, 5 miles north of Paskenta, Tehama County, California. "Upper Knoxville formation" of Stanton. Anderson (9), however, places the beds here in the lower part of the Shasta series, which he assigns to the Lower Cretaceous.

Type material: Holotype, U. S. Nat. Mus. 23044. Plastotype, Stanford Univ. 5999.

The specimen upon which this species is based is a mold of a right valve; it was thought by Stanton to represent an immature individual, as indicated by its small size (the specimen is only 7 mm. long and 4 mm. high). One change in Stanton's original description should be made. The beak, instead of being elevated and prominent, as described, projects scarcely at all beyond the hinge, so that, when viewed in profile, the dorsal margin of the shell presents a nearly straight line, little interrupted by the projection of the beak.

Stanton suggested that this species might prove to be identical with "*Nemodon fischeri* (d'Orbigny)" Whiteaves (=*Parallelodon* (*Gilbertwhitea*) *simillima* Whiteaves), a suggestion that may be correct, as the two species have somewhat the same shape. Inasmuch as the hinge of *P. tehamaensis* is unknown, its

EXPLANATION OF PLATE 27

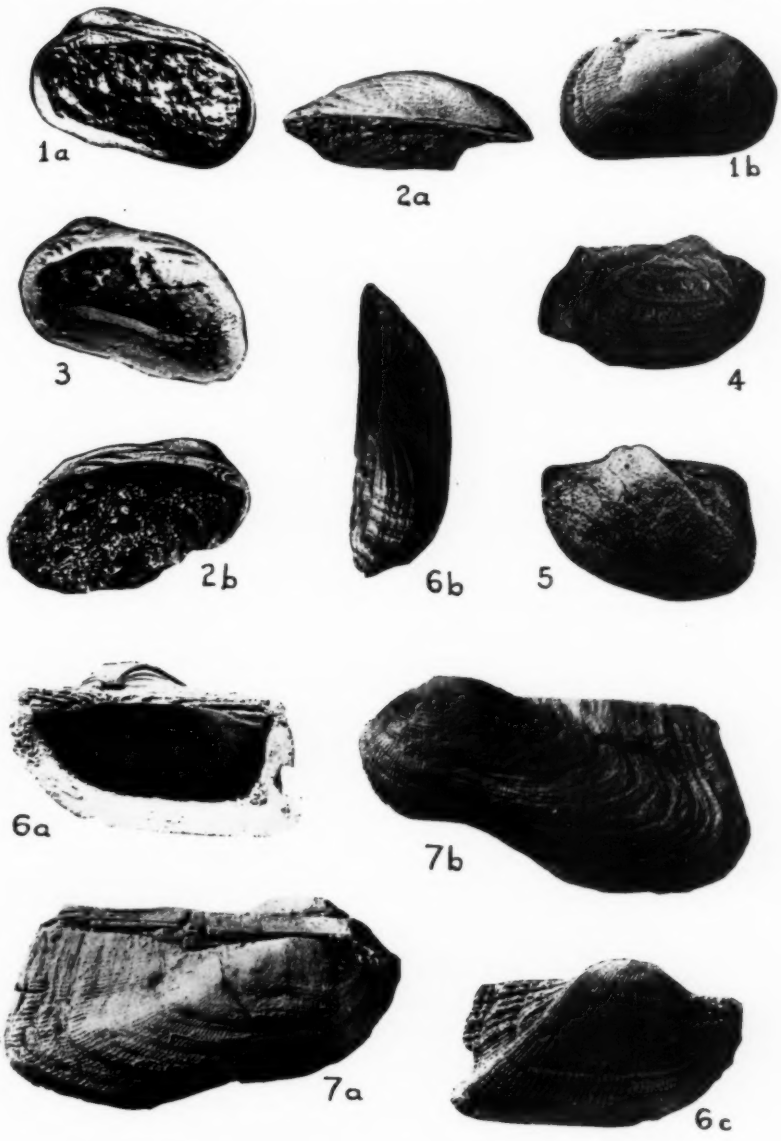
FIGS. *1–3*—*Porterius gabbi* (Dickerson). *1a*, *b*, Hypotype, Stanford Univ. 5254; loc. N.P.51. lower Porter formation (Oligocene), Porter Creek, Grays Harbor County, Washington; length 19 mm., ×1.5; *1a*, interior; *1b*, exterior of right valve. *2a*, *b*, Topotype, Univ. California 32429; Gries Ranch beds (Oligocene), near Little Falls, Lewis County, Washington; length 11 mm., ×3; *2a*, dorsal view; *2b*, interior of left valve. *3*, Hypotype, Stanford Univ. 5257; from same locality as specimen shown in figs. *1a*, *b*; length 9 mm., ×3.4; interior of right valve. (p. 178)

*4*—*Parallelodon* (*Nanonavis*) *vancouverensis* (Whiteaves). Holotype, U. S. Nat. Mus. 12398; Cretaceous, Comox, Vancouver Island, British Columbia; approximate length 19 mm., ×1.5; exterior of right valve. (Photograph by F. Stearns MacNeil). (p. 171)

*5*—*Cucullaea mathewsonii* Gabb (holotype of *"Arca" biloba* Weaver). Holotype, Univ. California 11884; Martinez formation (Paleocene), Univ. Calif. loc. 243, near town of Martinez, California; length 15.1 mm., ×2; exterior of left valve. (p. 176)

*6a–c*—*Parallelodon* (*Nanonavis*) *carinatum* (Sowerby) Woods, type species of *Nanonavis*. Topotype, Stanford Univ. 5272, Greensand, Albian; Blackdown, England; length 23.3 mm., ×1.7; *6a*, interior; *6b*, dorsal view; *6c*, exterior of right valve. (p. 170)

*7a*, *b*—*Parallelodon* (*Gilbertwhitea*) *simillima* (Whiteaves). Hypotype, Geol. Survey Canada, 8901; Yakoun formation, Cretaceous; Robber Point, Maud Island (Queen Charlotte Islands), British Columbia; length 41.8 mm., ×1.2; *7a*, exterior of right valve; *7b*, exterior of left valve. (p. 173)




Reinhart, Cretaceous and Tertiary Pelecypods

UNIV. OF MICH.

generic and subgeneric assignments are questionable.

Genus NEMODON Conrad, 1869

Type species: *Nemodon eufalensis* Conrad, 1869 (= *Nemodon conradi* Johnson, 1905, new name).

NEMODON? TEXTRINA (Stanton)

*Arca textrina* STANTON, *1895*, U. S. Geol. Survey, Bull. 133, pp. 14, 18, 50, 51, pl. 6, figs. 6, 7; *1897*, Jour. Geology, vol. 5, p. 596.—MERRILL, *1905*, U. S. Nat. Mus., Bull. 53, pt. 1, p. 57; syntypes in U. S. Nat. Museum.

Type locality: Near Stephenson's on the Cold fork of Cottonwood Creek, Tehama County, California. "Upper Knoxville formation," Cretaceous.

Type material: Syntypes, U. S. Nat. Mus. 23045. Plastotypes, Stanford Univ. 6001, 6002.

The description and figures leave the generic position of this species uncertain. Although the hinge of "*Arca*" *textrina* is not definitely known, Stanton reported finding young specimens, that he thought were probably referable to this species, with horizontal teeth at each end and transverse teeth at the center, thus supporting the view that the species belongs in the Parallelodontidae. This species seems similar in shape and ornamentation to *Nemodon* Conrad, to which genus Stanton suggested that it might be allocated.

Genus CUCULLAEA Lamarck, 1801

Type species: "*Arca*" *concamerata* Martini, 1777.

Subgenus CYPHOXIS Rafinesque, 1819
(= IDONEARCA Conrad, 1862)

Type species: *Cucullaea tippana* Conrad, 1858 (= *Cucullaea vulgaris* Morton, 1830).

CUCULLAEA (CYPHOXIS) GRAVIDA (Gabb)

*Arca gravida* GABB, *1864*, California Geol. Survey, Paleontology, vol. 1, p. 194, pl. 30, fig. 264.

*Cucullaea gravida* (Gabb). STANTON, *1896*, U. S. Geol. Survey, 17th Ann. Rept., pt. 1, p. 1023; Cretaceous of Benicia, California.

"*Arca*" *gravida* Gabb. STEWART, *1930*, Acad. Nat. Sci. Philadelphia, Special pub. 3, pp. 12, 76; assigned to *Cucullaea*.

*Arca decurtata* GABB, *1864*, California Geol. Survey, Paleontology, vol. 1, p. 195, pl. 31, figs. 265, 265*a*.

*Cucullaea decurtata* Gabb. ANDERSON, *1902*, California Acad. Sci., Proc., 3d ser., vol. 2, p. 30; lower Chico of Henley and Silverado.—PACKARD, *1916*, Univ. California, Dept. Geol. Sci., Bull., vol. 9, p. 146; Cretaceous of Santa Ana Mountains, California.

"*Arca decurtata*" Gabb. STEWART, *1930*, Acad. Nat. Sci. Philadelphia, Special pub. 3, pp. 12, 77; said to be a synonym of *Cucullaea gravida*.

Type locality: The type locality of *C. decurtata* and probably also of *C. gravida* is Wragg Canyon, Napa County, California. For further details, consult Stewart (1930, pp. 76, 77).

Type material: Holotypes of "*Arca*" *gravida* and "*A.*" *decurtata* are in the type collection of Univ. California, "*A.*" *gravida*, no. 11952; "*A.*" *decurtata*, no. 11987. Paratype of "*A.*" *gravida*, no. 4405, is in Acad. Nat. Sci. Philadelphia.

CUCULLAEA? EQUILATERALIS (Meek)

*Arca* (*Cucullaea*) *equilateralis* MEEK, *1864*, Albany Inst. Trans., vol. 4, art. 2, pp. 39–40.

*Arca? equilateralis* MEEK, *1876*, U. S. Geol. and Geog. Survey Territories, Bull., vol. 2, no. 4, p. 357, pl. 2, figs. 6, 6*a*,—MERRILL, *1905*, U. S. Nat. Mus., Bull. 53, pt. 1, p. 55; syntypes in U. S. Nat. Museum. (Not *Arca aequilateralis* Briart and Cornet, 1870.)

Type locality: Cretaceous of Nanaimo(?), Vancouver Island, British Columbia.

Type material: Syntypes, U. S. Nat. Mus. 12386. Plastotype, Stanford Univ. 6000.

The generic position of this species is difficult to determine, owing to the poor preservation of the type material. The shape suggests *Cucullaea*, the genus to which Meek originally assigned this species.

## EOCENE SPECIES

### "ARCA" COLUMBIANA Weaver and Palmer

*Arca columbiana* WEAVER and PALMER, *1922*, Univ. Washington [Seattle], Pub. in Geology, vol. 1, no. 3, p. 8, pl. 8, fig. 1; Eocene of Coal Creek (Cowlitz County), Washington.—STEWART, *1930*, Acad. Nat. Sci. Philadelphia, Special pub. 3, p. 257 ("*columbina*" by error); referred questionably to *Plagiocardium brewerii* (Gabb).

Type locality: Univ. Washington locality 337, Coal Creek, Cowlitz County, western Washington. Cowlitz formation, Eocene.

Type material: Holotype, C. E. Weaver collection. Plastotype, California Acad. Sci. type collection 1565.

Through the cooperation of Dr. C. E. Weaver I have been able to see the holotype, a slightly crushed right valve. Unfortunately, the hinge is not preserved, but enough of the specimen can be seen to say definitely that it is not one of the Arcidae. The suggestion made by Stewart that this is a specimen of *Plagiocardium brewerii* (Gabb) appears to be correct.

### "ARCA" BILOBA Weaver

Plate 27, figure 5

*Arca biloba* WEAVER, *1905*, Univ. California, Dept. Geol. Sci., Bull., vol. 4, no. 5, pp. 108, 110, 115, pl. 12, fig. 4; Martinez formation, near Martinez, California.—ARNOLD, *1906*, U. S. Geol. Survey, Prof. Paper 47, p. 12; Martinez, California.—?ANDERSON in DUMBLE, *1912*, Jour. Geology, vol. 20, p. 32; "lower chocolate shales" on Salt Creek, Coalinga district, California.—DICKERSON, *1914*, Univ. California, Dept. Geol. Sci., Bull., vol. 8, no. 6, pl. 7, fig. 8; stated to be the young of *Cucullaea mathewsonii* Gabb.

Nyst (10) lists an *Arca biloba* Roemer, 1839, from the Lower Jurassic of "Salzgitter, Hanovre." Roemer, however, appears not to have described an *Arca biloba*, although he did describe *Nucula biloba* (11), later referred to *Arca* by Nyst. *Arca biloba* Weaver is therefore a secondary homonym; in view of the fact that it appears to be a synonym of *Cucullaea mathewsonii*, *Arca biloba* need not be renamed.

Type locality: Martinez formation, Paleocene, Univ. California locality 243, "16½ centimeters east, 4½ south of northwest corner of Concord quadrangle—3 miles due south of Muir Station," Contra Costa County, California, near town of Martinez.

Type material: Holotype, Univ. California 11884; topotype 11885. Two other poorly preserved, unnumbered topotypes are in the same box.

This species was stated by Dickerson to be the young of *Cucullaea mathewsonii* Gabb, this conclusion being based upon finding, in beds containing that species, specimens of "*A.*" *biloba* in which the dentition was exposed and found to resemble that of *Cucullaea*. Because of this dentition, and of the occurrence of "*Arca*" *biloba* with *Cucullaea mathewsonii*, it seems reasonable to follow Dickerson in placing Weaver's species in the synonymy of *Cucullaea mathewsonii*. The dentition cannot be seen on the type specimens of "*Arca*" *biloba*, which are very poorly preserved.

## Genus PORTERIUS Clark, 1925

Type species: *Barbatia andersoni* Van Winkle, 1918.

The similarity of *Porterius* to *Pseudogrammatodon* Arkell, 1930, has already been pointed out (12). Although *Porterius* was originally described as a subgenus of *Parallelodon*, its relation to *Parallelodon* is not clear, and *Porterius* is therefore here considered a separate genus of the family Parallelodontidae.

### PORTERIUS WOODFORDI (Hanna)

*Barbatia woodfordi* M. A. HANNA, *1927*, Univ. California, Dept. Geol. Sci., Bull., vol. 16, no. 8, p. 273, pl. 27, figs. 1, 6, 8, 10; foll. p. 398; Rose Canyon shale, Eocene, La Jolla, California.—CLARK, *1929*, Stratigraphy and faunal horizons of the Coast Ranges of California, p. 14, pl. 6, fig. 17; typical Domengine species.

Type locality: Univ. California locality 5062, about 2½ miles south of mouth of Soledad Valley, in ocean cliff, La Jolla quadrangle, San Diego County, California. Rose Canyon shale, Eocene.

Type material: Holotype, Univ. Cali-

fornia 31062; paratypes 31063, 31064; hypotype, 32472.

Description of holotype (a young left valve): Shell minute, suboval, inequilateral, moderately inflated, delicate. Umbo moderately prominent, located one-fourth of length of shell from anterior end; beak prosogyrate. In profile the anterior, ventral, and posterior margins are gently rounded; hinge margin nearly straight, except for interruption of umbo.

Sculpture consists of about 58 radial ribs separated by narrower interspaces. Ribs simple throughout most of their length, but near ventral margin divided longitudinally by shallow grooves into two parts, as may be faintly distinguished on Hanna's figure (pl. 27, fig. 1) (In paratype no. 31063—Hanna, pl. 27, fig. 6—a much larger specimen, this dichotomizing takes place at nearly the same distance from tip of umbo as in the small holotype; but in the larger specimen it is still high up in the umbo, so that throughout most of its length each rib is divided into two parts by a longitudinal groove. Toward the ventral margin each part resembles a separate rib. Hanna's figure does not show this detail.) Ribs are evenly spaced over most of shell, but the anterior and posterior ribs are larger and more widely spaced. Regular concentric growth lines cut across the ribs.

Ligamental area narrow, not well preserved, located posterior to umbo. Hinge exposed in holotype, but the remainder of interior of shell is unknown. Hinge gently arched, posterior part longer than anterior; wider at extremities than in mesial region. Hanna's figure (pl. 27, fig. 10) shows clearly three strong, regular, inclined anterior teeth, and five posterior teeth, the posteriormost three lying parallel to hinge. The portion of the hinge directly under the beak is broken away.

In addition to the original type material, one other specimen that probably belongs to this species is known (Univ. California hypotype 32472). This specimen was collected by H. E. Vokes of the University of California from the northern part of the Coalinga district, Fresno County, California, Univ. California locality 1817, in SE¼ NW¼ sec. 15, T. 18 S., R. 14 E. The stratigraphic position is about 75 feet above the base of the so-called Meganos formation, middle Eocene, which here overlies Cretaceous Moreno shale, and approximately 1,600 feet below the base of the overlying Domengine sandstone as defined by Clark (Univ. California, Dept. Geol. Sci., Bull., vol. 16, no. 5, pp. 103–106, 1906). *Turritella andersoni* Dickerson is abundant at the same locality.

I have compared this specimen with Hanna's original material. The Coalinga specimen is externally similar to the large paratype, no. 31063 (Hanna, 1927, pl. 27, fig. 6), the hinge of which, however, is only partly preserved. On hypotype 32472 both the hinge and ligamental area are better preserved, affording a fair conception of their structure. The hinge is similar to that of *Porterius gabbi* (Dickerson) in its general features. On hypotype 32472 there are about four diagonally-placed anterior teeth; only two posterior teeth can be identified, arranged nearly parallel to hinge margin. The narrow ligamental area is confined to the posterior of umbo, as in *P. gabbi*, leaving the anterior part of the dorsal margin devoid of ligamental grooves. Although the hinge on hypotype 32472 differs somewhat from that of the holotype of *P. woodfordi*, this fact need not necessarily indicate that the two specimens do not belong to the same species, because the holotype is an immature specimen in which the hinge has not become fully developed. Furthermore, the external resemblance of the Coalinga specimen to paratype 31063 is great; and if the two specimens are not conspecific they are at least closely related.

*Dimensions of type specimens (in millimeters)*: Holotype 31062 (left valve), length 3.4, height 2.7, convexity 0.7. Paratype 31063 (right valve), length

12.5, height 8.5, convexity 3.0. Paratype 31064 (right valve), length 2.7, height 1.8, convexity 0.5. Hypotype 32472 (left valve), length 14, height 9.0, convexity 3.0.

*Comparisons.*—As pointed out, this species resembles *Porterius gabbi* (Dickerson) in hinge structure; and inasmuch as these two species are also similar in shape and ornamentation (both species possess dichotomizing radial ribs) it seems evident that *P. woodfordi* likewise belongs to *Porterius*. The two species may be distinguished by the fact that the radial ribs are much coarser and more distinct on *P. gabbi* than on *P. woodfordi*.

## GENERIC POSITION UNKNOWN

### "ARCA" CLARKI Dickerson

*Arca clarki* DICKERSON, *1916*, Univ. California, Dept. Geol. Sci., Bull., vol. 9, no. 17, pp. 376, 444, 481, pl. 37, fig. 12; Eocene of Mount Diablo, central California. —M. A. HANNA, *1927*, Univ. California, Dept. Geol. Sci., Bull., vol. 16, no. 8, p. 273; compared to "*Barbatia*" *woodfordi* Hanna.

Type locality: Univ. Califorina locality 733, Contra Costa County, California; elevation 1150 feet; middle of E½ SE¼ sec. 22, T. 1 S., R. 1 E., east side of Riggs Canyon on ridge above barn in canyon. "Domengine" formation, Eocene.

Type material: Holotype, Univ. California 11801.

Having exposed the hinge of the holotype, I find that this species does not belong to the Arcidae. The dentition consists of two heavy, ventrally-converging teeth on each side of the hinge plate; in the center of the hinge, directly beneath the beaks, is a deep central depression. The hinge, so far as can be seen, somewhat resembles that of *Limopsis*, but externally this specimen resembles *Pteria* or *Pecten*. Better material is necessary before this species can be assigned to the proper genus. I have visited the type locality of this species but was unable to find topotypes.

## OLIGOCENE[1] SPECIES

### Genus PORTERIUS Clark, 1925

### PORTERIUS GABBI (Dickerson)

Plate 27, figures 1*a*, *b*, 2*a*, *b*, 3

*Barbatia gabbi* DICKERSON, *1917*, California Acad. Sci., Proc., 4th ser., vol. 7, no. 6, pp. 159, 161, 167, pl. 27, fig. 4; Gries Ranch beds, Gries Ranch, near Little Falls (Lewis County), Washington.

*Barbatia andersoni* VAN WINKLE, *1918*, Univ. Washington [Seattle] Pub. in Geology, vol. 1, no. 2, pp. 75, 81, 82, pl. 6, fig. 2; lower Lincoln formation, Oligocene, near Porter (Grays Harbor County), Washington.

*Parallelodon* (*Porterius*) *andersoni* (Van Winkle). CLARK, *1925*, Univ. California Dept. Geol. Sci., Bull., vol. 15, no. 4, pp. 79, 80, pl. 8, fig. 3, pl. 9, figs. 1, 6.

"*Barbatia*" *andersoni* Van Winkle. REINHART, *1935*, Mus. royale histoire nat. Belgique, Bull., tome 11, no. 13, p. 7; compared to "*Arca*" *adversidentata* Deshayes.

Type locality: Near town of Little Falls, Lewis County, Washington. California Acad. Sci. locality 181, on east bank of Cowlitz River, just back of ranch house. Gries Ranch beds, Oligocene.

Type material: Holotype of *Porterius gabbi*, California Acad. Sci. 385; hypotype, Univ. California 32429. Holotype of "*Barbatia*" *andersoni*, C. E. Weaver collection; hypotypes, Stanford Univ. 5254, 5256, 5257.

Comparison of "*Barbatia*" *andersoni* with "*B.*" *gabbi* shows no basis for separating the two species. On plate 27 are figured specimens from the type locality of *P. gabbi* (fig. 2*a*, *b*) and from the type locality of "*Barbatia*" *andersoni* (figs. 1*a*, *b*, 3). The specimens shown in figs. 1*a*, *b* and 3 were previously illustrated by B. L. Clark (1918), who stated that they were the basis for his diagnosis of *Porterius*. These specimens, in the type

[1] "Oligocene" is used here in the sense employed by Pacific Coast writers to refer to strata younger than the Tejon and older than the Vaqueros formation. It refers, therefore, to formations included in the Refugian stage by Schenck and Kleinpell (*Am. Assoc. Petroleum Geologists, Bull.*, vol. 20, no. 2, pp. 215–225, 1936).

collection at Stanford University, are numbered 5254 and 5257 instead of 11 and 12, the numbers used by Clark.

In addition to its occurrence in the Gries Ranch and Lincoln formations, this species has also been collected from the Keasey formation, Oligocene, of Columbia County, Oregon, by H. G. Schenck and J. T. Holman (Schenck collection, Stanford University, nos. 406 and 411) at the following places:

Locality H. 40. Near center of NE¼ sec. 8, T. 4 N., R. 4 W.; 1 mile south of Vernonia on road to Timber.

Locality H. 62. Center of E. line sec. 4, T. 4 N., R. 4 W.; railroad cut in Oregon-American Lumber Co. yards; just south of highway; in eastern part of town limits of Vernonia.

Locality H. 63. Near center of SW¼ sec. 30, T. 5 N., R. 4 W.; prominent exposure in road cut along Rock Creek; road to Keasey. Also in railroad cut just below.

*Comparisons.*—This species is similar in general features to "*Arca*" *adversidentata* Deshayes, from the Lutetian, Eocene, of the Paris Basin (13). Closer is the resemblance of *Porterius gabbi* to "*Cucullaria*" *tridentata* von Ihering (14), from the "Suprapatagonian beds" of Patagonia, a species which likewise belongs to *Porterius*. "*Arca* (*Cucullaria*)" *ozarkensis* Aldrich (15), from the Eocene Bashi formation of Alabama, is another related species.

## REFERENCES


1. Reinhart, P. W., *Mus. royal histoire nat. Belgique, Bull.*, tome 11, no. 13, pp. 1–68, 1935.
2. Meek, F. B., and Hayden, F. V., *Acad. Nat. Sci. Philadelphia, Proc.*, p. 51, 1858.
3. Davis, C. H., New species from the Santa Lucia Mountains, California: *Jour. Geology*, vol. 21, no. 5, p. 454, 1913. Consult also Nomland, J. O., and Schenck, H. G., Cretaceous beds at Slate's Hot Springs, California: *Univ. California, Dept. Geol. Sci., Bull.*, vol. 21, no. 4, p. 45, 1932.
4. Arkell, W. J., *Geol. Mag.*, vol. 67, pl. 15, 1930.
5. *Idem*, p. 299, fig. 4.
6. *Idem*, pp. 297–310, 337–352.
7. For illustrations consult Healy, Maud, *Palaeontologia Indica*, n. ser., vol. 2, mem. 4, pl. 1, fig. 20*a–c*.
8. Anderson, F. M. and Hanna, G. D., Cretaceous geology of Lower California: *California Acad. Sci., Proc.*, 4th ser., vol. 23, no. 1, p. 8, 1935.
9. Anderson, F. M., Knoxville-Shasta succession in California: *Geol. Soc. America, Bull.*, vol. 44, p. 1241, geologic map, fig. 1. "Shelton" is shown here in sec. 9, T. 24 N., R. 6 W.
10. Nyst, H., Tableau synoptique et synonymique des espèces vivantes et fossiles de la famille des Arcacées, pt. 1, Genre *Arca: Acad. royale Belgique, Mém.*, tome 22, p. 14, 1848.
11. Roemer, F., *Verst. ool. Gebirges*, pl. 19, fig. 11, 1839.
12. Reinhart, *op. cit.*, p. 7.
13. Cossmann, M., and Pissarro, G., *Iconographie complète des coquilles fossiles de l'Éocène environs de Paris*, vol. 1, pl. 37, fig. 110–63, 1904–06.
14. Von Ihering, H., *Revista do Museu Paulista*, vol. 2, p. 237, pl. 4, fig. 22; pl. 5, fig. 28, 1897.
15. Aldrich, T. H., New Eocene species from Alabama: *Bull. Am. Paleontology*, vol. 9, no. 37, pp. 22, 23, pl. 3, figs. 13, 14, 1921.


## SELECTED BIBLIOGRAPHY


D'Archiac, Vicomte, Description géologique du Département de l'Aisne: *Soc. géol. France, Mém.*, tome 5, 2e part, p. 374, 1843.

Arkell, W. J., The generic position and phylogeny of some Jurassic Arcidae: *Geol. Mag.*, vol. 67, no. 793, pp. 297–310; no. 794, pp. 337–352, 1930.

Buckman, J., in Murchison, *Outline of the geology of Cheltenham*, Appendix, p. 99, 1845.

Clark, B. L., Pelecypoda from the marine Oligocene of western North America: *Univ. California, Dept. Geol. Sci., Bull.*, vol. 15, no. 4, pp. 69–136, 1925.

Conrad, T. A., Observations on a group of Cretaceous fossil shells found in Tippah County, Mississippi, with descriptions of 56 new species: *Acad. Nat. Sci. Philadelphia, Jour.*, 2d ser., vol. 3, pp. 323–336, 1858.

—— Descriptions of new fossil Mollusca, principally Cretaceous; *Am. Jour. Conchology*, vol. 5, pp. 96–103, 1869.

Cossmann, M., review of Beushausen, "Die Lamellibranchiaten des rheinischen Devons" (Preuss. geol. Landesanstalt Abh., n. f., H. 17, 1895): *Rev. Crit. Paléozool.*, année 1897, p. 93, 1897.

Crickmay, C. H., The Jurassic rocks of Ashcroft, British Columbia: *Univ. California, Dept. Geol. Sci., Bull.*, vol. 19, no. 2, pp. 23–74, 1930.

Dickerson, R. E., Fauna of the Martinez Eocene of California: *Univ. California, Dept.*

*Geol. Sci., Bull.*, vol. 8, no. 6, pp. 61–180, 1914.

—— Stratigraphy and fauna of the Tejon Eocene of California: *Univ. California, Dept. Geol. Sci., Bull.*, vol. 9, no. 17, pp. 363–524, 1916.

—— Climate and its influence upon the Oligocene faunas of the Pacific Coast, with descriptions of some new species from the *Molopophorus lincolnensis* zone: *Calif. Acad. Sci., Proc.*, 4th ser., vol. 7, no. 6, pp. 157–192, 1917.

GABB, W. M., Description of the Cretaceous fossils: *California Geol. Survey, Paleontology*, vol. 1, pp. 57–243, 1864.

HANNA, M. A., An Eocene invertebrate fauna from the La Jolla Quadrangle, California: *Univ. California, Dept. Geol. Sci., Bull.*, vol. 16, no. 8, pp. 247–398, 1927.

HEALEY, MAUD, The fauna of the Napeng beds or the Rhaetic beds of Upper Burma: *Paleontologia Indica*, new ser., vol. 2, Mem. 4, pp. 13, 14. 1908.

JOHNSON, C. W., Annotated list of the types of invertebrate Cretaceous fossils in the collection of the Academy of Natural Sciences, Philadelphia; *Acad. Nat. Sci. Philadelphia, Proc.*, vol. 57, pp. 4–28, 1905.

MEEK, F. B., Descriptions of new organic remains from the Cretaceous rocks of Vancouver's Island: *Albany Inst., Trans.*, vol. 4, art. 2, pp. 37, 49, 1864.

—— and HAYDEN, F. V., Description of new organic remains collected in Nebraska Territory . . . together with some remarks on the geology of the Black Hills and portions of the surrounding country: *Acad. Nat. Sci. Philadelphia, Proc.*, pp. 41–59, 1858.

—— and HAYDEN, F. V., Systematic catalogue, with synonyma, etc., of Jurassic, Cretaceous, and Tertiary fossils collected in Nebraska Territory: *Acad. Nat. Sci. Philadelphia, Proc.*, pp. 417–432, 1860.

—— and WORTHEN, A. H., Descriptions of Paleozoic fossils from the Silurian, Devonian, and Carboniferous rocks of Illinois and other western States: *Chicago Acad. Sci., Proc.*, vol. 1, pp. 22, 23, 1866.

REINHART, P. W., Classification of the pelecypod family Arcidae: *Mus. royal histoire nat. Belgique, Bull.*, tome 11, no. 13, pp. 1–68, 1935.

STANTON, T. W., Contributions to the Cretaceous paleontology of the Pacific coast, the fauna of the Knoxville beds: *U. S. Geol. Survey, Bull.* 133, pp. 1–132, 1895.

STEWART, R. B., Gabb's California Cretaceous and Tertiary type lamellibranchs: *Acad. Nat. Sci. Philadelphia, Special Pub.* 3, pp. 1–314, 1930.

VAN WINKLE, K. E. H., Paleontology of the Oligocene of the Chehalis Valley, Washington: *Univ. Washington [Seattle] Pub. in Geology*, vol. 1, no. 2, pp. 69–97, 1918.

WEAVER, C. E., Contribution to the paleontology of the Martinez group: *Univ. California, Dept. Geol. Sci., Bull.*, vol. 4, no. 5, pp. 101–123, 1905.

—— and PALMER, K. VAN WINKLE, Fauna from the Eocene of Washington: *Univ. Washington [Seattle] Pub. in Geology*, vol. 1, no. 3, pp. 1–56, 1922.

WHITEAVES, J. F., On the fossils of the Cretaceous rocks of Vancouver and adjacent islands in the Strait of Georgia: *Canada Geol. Survey, Mesozoic fossils*, vol. 1, pt. 2, pp. 93–190, 1879.

—— On the fossils of the coal-bearing deposits of the Queen Charlotte Islands: *Canada Geol. Survey, Mesozoic fossils*, vol. 1, pt. 3, pp. 191–262, 1884.

—— On some additional or imperfectly understood fossils from the Cretaceous rocks of the Queen Charlotte Islands, with a revised list of the species from these rocks: *Canada Geol. Survey, Mesozoic fossils*, vol. 1, pt. 4, pp. 263–307, 1900.

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# THREE NEW SPECIES OF THE PELECYPOD FAMILY ARCIDAE FROM THE PLIOCENE OF CALIFORNIA

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ABSTRACT

Three species of Arcidae from the Pliocene of Fugler Point, near Santa Maria, Santa Barbara County, California, are new: *Arca* (*Arca*) *sisquocensis*, *Arca* (*Arca*) *santamariensis*, and *Barbatia* (*Fugleria*) *pseudoillota*, the last-named species belonging to a new subgenus, *Fugleria*.

In 1933 Mr. Alex Clark of the Shell Oil Co. turned over to me some specimens of Arcidae which he had collected from the Pliocene asphalt beds at Fugler Point, 7½ miles southeast of Santa Maria, Santa Barbara County, California. He describes this locality as follows:

> Exposure in face of terrace at side of road 1 mile north of Gary, ¼ mile west of junction of Sisquoc and Cuyama Rivers. Almost exact center of NE¼ sec. 35, T. 10 N., R. 33 W., Lompoc quadrangle. Abundant fossils in fine-grained, asphaltic sands dipping 35° to the southwest and overlain by terrace deposits.

Comparison of these specimens with fossil and Recent arcids from California and elsewhere shows that three new species are represented, which are described in this paper. Two of the new species are analogous to Recent species from the Panamic province. One has some resemblance to an Early Tertiary species from Washington.

The beds at Fugler Point were mapped as the "Fernando" formation by Arnold and Anderson (1). Although the very small, isolated area of Fernando shown on their map at the contact between Quaternary terrace deposits and alluvium is not labelled with the Fernando symbol, it is definitely assigned to the Fernando in the text (p. 57).

Arnold and Anderson list a number of species from the asphalt mine at Fugler Point, their locality 4475. The Pliocene age of the beds at this locality is shown by the presence of several characteristic species, including *Psephaea oregonensis* (Dall), *Clinocardium meekianum* (Gabb), and *Anadara trilineata* (Conrad). The entire molluscan faunal assemblage is considered by Alex Clark (2) to indicate an age corresponding to the San Diego formation as interpreted by Grant and Gale (3)—that is, older than the Santa Barbara formation and younger than the marine Pliocene beds in Elsmere Canyon, which these authors correlate with the Jacalitos formation.

## DESCRIPTION OF SPECIES

### Genus ARCA Linné, 1758

Type species: *Arca noae* Linné, 1758
Subgenus ARCA, s. s.

I have previously pointed out (4) the uncertainty regarding the type species of *Arca* and the possibility that *Arca*

*antiquata* Linné might ultimately have to be taken as the genotype. In June 1932 I submitted this question to the International Commission on Zoological Nomenclature for its consideration, but so far no decision has been reached by that body. In case the Commission decides in favor of *Arca noae* as the genotype of *Arca*, the nomenclature used in this paper will remain unchanged. However, if it rules in favor of *A. antiquata*, the two species here described as *Arca*, s.s., will have to be called *Navicula*.

### Arca (Arca) sisquocensis Reinhart, n. sp.
Plate 28, figures 1–3

*Type material.*—Holotype, California Inst. Technology, 1382. Plastotype, Stanford Univ. Schenck collection, 1954.

*Description of holotype.*—Small, well-preserved right valve, elongate in outline, moderately inflated, slightly inequilateral.

Profile: Anterior margin evenly rounded; ventral margin straight, nearly parallel to hinge margin; posterior margin straight, forming acute angle where it intersects ventral margin, and meeting hinge margin at angle of 45°. Umbo located just anterior to center of shell, projecting slightly. An unusually sharp ridge extends from umbo to posterior ventral corner; above this ridge, shell is concave. A faint medial sulcus extends from byssal gape, upward a short distance toward umbo.

Sculpture: About 40 radial ribs, with occasional small inter-ribs. On posterior slope, ribs are large and dichotomizing; elsewhere, simple and ornamented with closely-spaced nodes. The five anteriormost ribs are as large as the posterior ones, but do not dichotomize. Concentric growth-lines are not prominent, but two distinct concentric bands may be distinguished, and several less distinct ones. Ligamental area narrow in front of umbo, wide behind, there becoming noticeably excavated. About two right-angled, chevron-shaped grooves directly beneath umbo. Hinge straight, narrow, only slightly wider at extremities than at center; thirty-two teeth, small and granular at center, increasing regularly in size toward extremities of hinge; teeth converge ventrally, the anterior more sharply than the posterior. Muscle scars distinct, notable because of a raised flange bordering inner side of each scar, the posterior flange being the larger. (Such raised flanges are ordinarily not present on *Arca s.s.*, although they are present in *Striarca*, and in *Noetia* and *Trigonarca* a flange is developed on the inner side of the posterior muscle scar; these flanges are therefore of interest, and have been previously mentioned) (5). Inner margin of shell crenulated, especially at extremities. Narrow byssal gape near center. Pallial line simple; within this line, inner side of shell faintly striated by radial lines.

Dimensions of holotype (in millimeters): Length 15.4; height 7.6; convexity (right valve) 4.

*Occurrence.*—Pliocene asphalt beds of Fugler Point, 7½ miles southeast of

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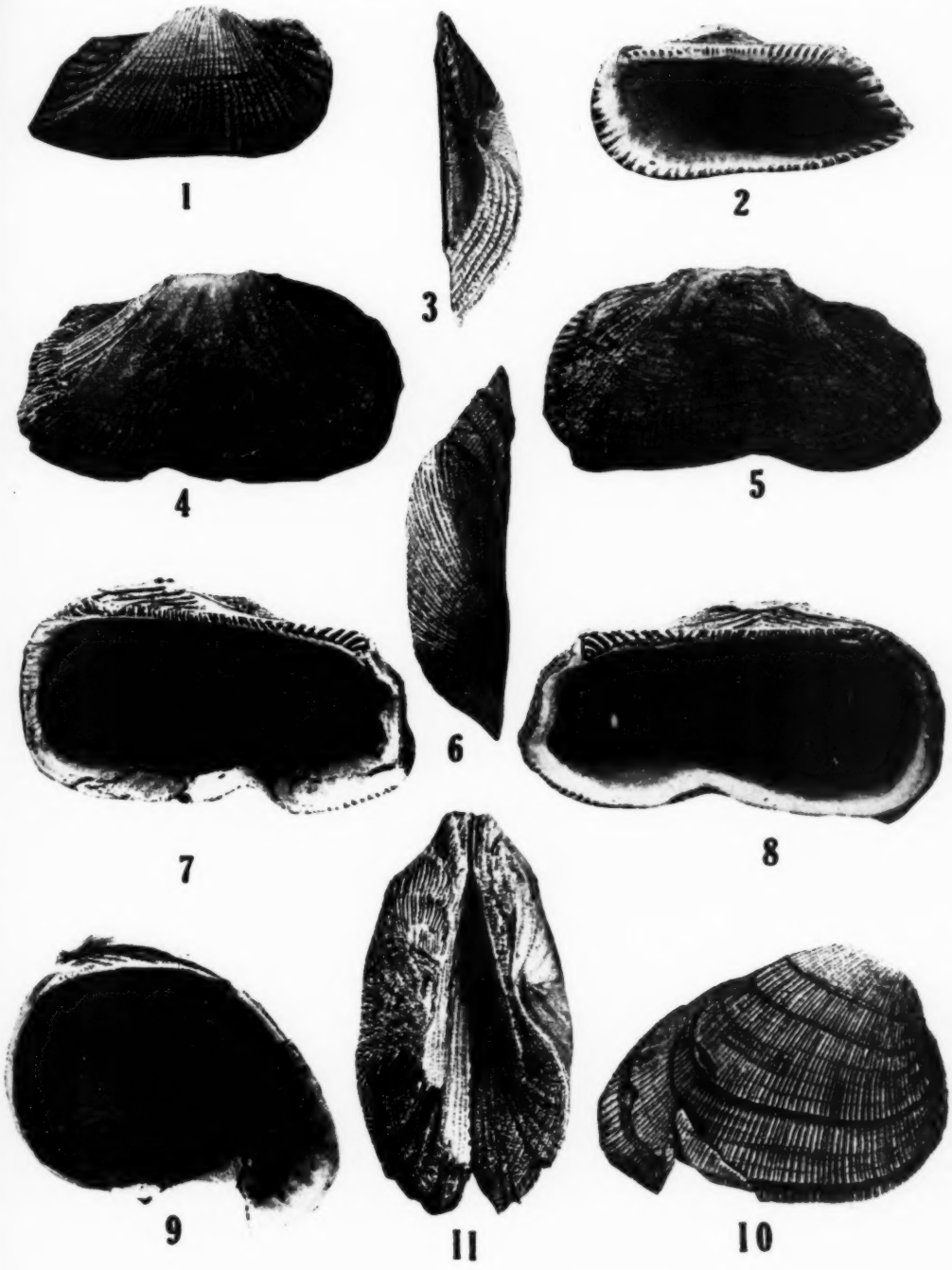
Explanation of Plate 28

Specimens illustrated are in the type collection of the California Institute of Technology; all are from the Pliocene of Fugler Point, Santa Barbara County, California. (Photographs retouched by E. H. Quayle. Enlargements stated approximately.)

Figs. *1–3*—*Arca* (*Arca*) *sisquocensis* Reinhart, n. sp. Holotype no. 1382, right valve, length 15.4 mm. *1*, Exterior right valve; *2*, interior; *3*, dorsal view. ×3. (p. 182)

*4, 5, 7, 8, 11*—*Arca* (*Arca*) *santamariensis* Reinhart, n. sp. Holotype no. 1381, length 35.6 mm. *4*, Exterior of right valve, *5*, exterior of left valve; *7*, interior of right valve; *8*, interior of left valve; *11*, dorsal view of valves in attached position. ×1.6. (p. 183)

*6, 9, 10*—*Barbatia* (*Fugleria*) *pseudoillota* Reinhart, n. sp. Holotype no. 1383, right valve, length 33.5 mm. *6*, Dorsal view; *9*, interior; *10*, exterior. ×1.5. (p. 184)




Reinhart, Pliocene Pelecypods

UNIV. OF MICH.

Santa Maria, Santa Barbara County, California (type).

Santa Barbara formation (upper Pliocene or lower Pleistocene), on steep hillside at top of sand pit just south of intersection of Mountain Ave. and Victoria St., Santa Barbara, California, at north end of Packard's Hill, Dr. F. C. Clark, collector. I have seen one well-preserved, young right valve from this locality, with length 8 mm.; height 3.6 mm.; convexity 2.2 mm. This specimen, to which my attention was called by Dr. U. S. Grant, is now in the collection of the University of California at Los Angeles, cat. no. 3524. Dr. S. S. Berry also reports that he has found this species at the Bath House cliff at Santa Barbara.

Hilltop Quarry, San Pedro, California; six specimens from the pit in the quarry floor at the base of the sandy bluff, S. S. Berry, collector. Dr. Berry considers the beds containing them as lower Pleistocene.

*Comparisons.*—This new species is similar in its general features to *Arca washingtoniana* Dickerson (6) from the Gries Ranch beds of Washington; however, the two species are readily separable by numerous details, as, for example, the ornamentation. In *A. washingtoniana* all of the ribs dichotomize, and concentric growth lines are prominent, whereas in the new species, only the posteriormost ribs dichotomize, and concentric bands are only feebly developed.

Surprisingly, the new species rather closely resembles the Recent Mediterranean and Atlantic species, *Arca tetragona* Poli, 1895, which has been well figured by Bucquoy, Dautzenberg, and Dollfus (7). A comparison of *A. sisquocensis* with specimens of *A. tetragona* in the Oldroyd collection (no. 341), Stanford University, clearly brings out this resemblance. These specimens, in addition to resembling *A. sisquocensis* in general shape and sculpture, also have a distinct flange bordering the posterior muscle scar, although none is present on the anterior scar.

ARCA (ARCA) SANTAMARIENSIS
Reinhart, n. sp.
Plate 28, figures 4, 5, 7, 8, 11

*Type material.*—Holotype, California Inst. Technology, 1381. Plastotype, Stanford University, Schenck collection, 1955.

*Description of holotype (only specimen known).*—Both valves of fairly well-preserved specimen, moderately large, elongate, equilateral, inflated. Profile of anterior margin evenly rounded; ventral margin roughly parallel to hinge; notched at center by byssal gape; posterior margin irregular, truncating ventral margin; umbones centrally placed, fairly large, but broken at top. Slightly curved umbonal ridge extends from umbo to posterior ventral margin; above this ridge is a groove. Medial sulcus extends upward a short distance from byssal gape. Sculpture, approximately 100 radial ribs, irregular in size and spacing, and having tendency to dichotomize; ribs larger at anterior and posterior ends of shell than elsewhere. Nodes on ribs inconspicuous, arranged in concentric bands; most prominent on posterior slope. Growth lines fairly prominent, following outline of shell. Ligamental area, with both valves together, resembles an arrowhead (pl. 28, fig. 11), pointing anteriorly when viewed from above; inclined at anterior end, but nearly flat and wider toward posterior; four or five chevron-shaped grooves between beaks; in addition, ligamental area sculptured on exterior with a number of longitudinal lines, continuations of concentric growth lines. Hinge narrow, straight, slightly wider at extremities than at center; teeth about 45 in number; a few anterior and posterior teeth are V-shaped or curved; teeth converge ventrally at extremities of hinge. Muscle scars distinct, oval-shaped, nearly equal in size. Inner margin of shell nearly smooth, with feeble crenulations at posterior end; small byssal gape. Pallial line simple, prominent.

Dimensions of holotype (in milli-

meters): Length 35.6; height 19; convexity (both valves together) 19.

*Type locality.*—Pliocene asphalt beds at Fugler Point, 7½ miles southeast of Santa Maria, Santa Barbara County, California. Known only from the type locality.

*Comparisons.*—This new species is somewhat similar to the Recent species *Arca mutabilis* (Sowerby), from the Gulf of California and Panama, but the two species differ in ornamentation as well as in the shape of the ligamental area. *A. mutabilis* has been figured by Maury (8).

Genus BARBATIA Gray, 1842

Type species: *Arca barbata* Linné, 1758

Subgenus FUGLERIA Reinhart, n. subgen.

Type species: *Barbatia* (*Fugleria*) *pseudoillota* Reinhart, n. sp., from the Pliocene of Fugler Point. The ligament of *Fugleria* is similar to that of *Acar*, being confined chiefly to the posterior of the beaks, but the hinge is different, the posterior teeth of *Fugleria* being only feebly developed or even totally absent, as in the type species. *Fugleria*, in addition, lacks the elevated muscle scars and reticulate sculpture of *Acar*.

Besides the type species, *Fugleria* includes the Recent tropical Pacific Coast species, *Barbatia illota* (Sowerby), which has been figured by Maury (9). *B. illota* was included by Maury and by Lamy (10) in the subgenus *Acar*.

*Arca* (*Acar*) *millifila* Dall (11), from the Pliocene of Florida, may belong to *Fugleria*, but I have not seen a specimen.

BARBATIA (FUGLERIA) PSEUDOILLOTA
Reinhart, n. sp.
Plate 28, figures 6, 9, 10

Type material.—Holotype, California Inst. Technology 1383; paratype, California Inst. Technology 1384. Plastotypes, Stanford Univ., Schenck collection, 1956, 1957.

*Description of holotype.*—Fairly well-preserved right valve, elongate-oval in outline, inequilateral, little inflated. Beak placed near anterior end, prosogyrate. Profile of anterior margin of shell rounded; ventral margin nearly straight; byssal gape inconspicuous if present; posterior margin sharply-rounded ventrally, straighter dorsally; dorsal margin formed by large umbo, beyond which hinge margin projects only slightly on either side. A broad ridge extends from umbo to posterior ventral margin; in front of this is a very shallow medial depression. Sculpture of about 95 radial ribs, coarser on posterior slope than elsewhere; ribs spaced with fair regularity; small inter-ribs occasionally developed. Five prominent concentric growth lines present, as well as many inconspicuous ones. Ligamental area narrow, confined mainly to posterior of umbo, although extending slightly in front; about four chevron-shaped ligamental grooves present, of which the upper two do not extend anterior to beak. Hinge arched, very narrow; about 7 small, granular teeth, at anterior end of hinge only; no posterior teeth either on holotype or paratype. Interior of shell of holotype is mainly concealed by matrix, but in paratype (no. 1384), a young specimen, the interior of the shell is entirely exposed; this appears smooth, but under magnification is seen to have numerous fine radial striations. Muscle scars indistinct. Inner margin of shell smooth. Pallial line slightly indented.

Dimensions (in millimeters): Holotype, California Inst. Technology 1383, length 33.5; height 31; convexity (right valve) 9. Paratype, California Inst. Technology 1384, length 17; height 12; convexity (right valve) 4.5.

*Occurrence.*—Pliocene asphalt beds at Fugler Point, 7½ miles southeast of Santa Maria, Santa Barbara County, California (type).

An imperfect specimen in paleontological collection of Univ. California collected by S. Buckholtz and F. Agee from upper Pico formation of Elsmere Canyon, Los Angeles County, California, stratigraphically about 100 feet

below base of Saugus formation; identification doubtful.

*Comparisons.*—This species is related to *Barbatia illota* (Sowerby), a Recent tropical Pacific Coast species, which, as already stated, likewise belongs to the subgenus *Fugleria*. However, although the posterior teeth on this species are not strongly developed, they are at least present.

The general similarity to *Barbatia millifila* (Dall) has already been suggested; that species, however, to judge from Dall's illustrations, differs in the hinge, possessing well-developed posterior teeth which join the anterior ones without a break.

## REFERENCES


1. ARNOLD R., and ANDERSON, R., Geology and oil resources of the Santa Maria oil district, Santa Barbara County, California: *U. S. Geol. Survey, Bull.* 322, pp. 57–60, pl. 1, 1907.
2. Letter to me dated May 8, 1933.
3. GRANT, U. S. and GALE, H. R., Pliocene and Pleistocene Mollusca of California: *San Diego Soc. Nat. Hist., Mem.*, vol. 1, p. 61, etc., 1931.
4. REINHART, P. W., *Mus. royal histoire nat. Belgique, Bull.*, tome 11, no. 13, pp. 15–17, 1935.
5. *Idem*, p. 8, footnote 8.
6. DICKERSON, R. E., Climate and its influence upon the Oligocene faunas of the Pacific Coast, with descriptions of some new species from the *Molopophorus lincolnensis* zone: *California Acad. Sci., Proc.*, 4th ser., vol. 7, no. 6, pp. 159, 166, pl. 27, fig. 2*a*, *b*.
7. BUCQUOY, E., DAUTZENBERG, P., and DOLLFUS, G., *Les mollusques marins du Roussillon*, tome 2, Pelecypoda, fasc. 5, pl. 31, figs. 1–5, 1891.
8. MAURY, C. J., The Recent Arcas of the Panamic province: *Palaeontographica Americana*, vol. 1, no. 4, pl. 1, fig. 5, 1922.
9. *Idem*, pl. 2, fig. 8.
10. LAMY, E., Révision des *Arca* vivants du Muséum d'histoire naturelle de Paris: *Jour. conchyliologie*, vol. 55, no. 1, pp. 91, 92, 1907.
11. DALL, W. H., Contributions to the Tertiary fauna of Florida: *Wagner Free Inst. Sci., Trans.*, vol. 3, pt. 6, pl. 56, figs. 21, 24, 1903.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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 3, PP. 186–188, PL. 29, APRIL, 1937

# *CONCHOPELTIS* WALCOTT, AN ORDOVICIAN GENUS OF THE CONULARIIDA

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ABSTRACT

*Conchopeltis alternata* Walcott, genotype of *Conchopeltis* Walcott, is redescribed and illustrated from the type material. It is shown that the organism had a quadrilateral radial symmetry, and four symmetrically arranged pairs of markings resembling muscle scars. This quadrilateral radial symmetry of *Conchopeltis* is incompatible with the bilateral plan of organization of the gastropods but is strikingly similar to that of the Conularia. Such forms would appear to be less out of place appended to either the class Hydrozoa or the class Scyphozoa of the Coelenterata than to the Mollusca. If the class Conulariida were so placed it might well include, besides the Conulariidae (*Conularia* and *Conchopeltis*), the radially symmetrical Tentaculitidae.

In connection with some work on the genotype species of Paleozoic gastropod genera I have had occasion to restudy Walcott's syntypes of *Conchopeltis alternata*, genotype of *Conchopeltis* Walcott by subsequent designation of Miller, 1889 (1). The syntypes, deposited in the paleontological collections of the Museum of Comparative Zoology at Harvard University, were made available to me through the great kindness of Mr. W. E. Schevill.

Very little has been published on this remarkable form. Walcott's original description of 1875 (2) was very brief and without illustrations. Indeed the only illustrations that have been published are some rather crude and inadequate pen-and-ink sketches made for Prof. H. N. Winchell in 1892 and reproduced by Ulrich and Scofield in 1897 (3). A redescription with photographic illustrations may, therefore, be of interest.

CONCHOPELTIS ALTERNATA Walcott
Plate 29, figures 1–5

*Conchopeltis alternata* WALCOTT, *1875*, New York State Mus. Nat. Hist., 28th Ann. Rept., doc. ed., 1875, p. 93; mus. ed., 1879, p. 93.—MILLER, *1889*, North American Geol. and Paleont., p. 400.—ULRICH and SCOFIELD, *1897*, Geol. Minnesota, vol. 3, pt. 2, p. 823, fig. 2.

Shell in the form of a low, acuminate cone, symmetrically and radially four lobed, the lobes defined by four shallow grooves that run from the centrally placed apex to four concave reentrants in the margin of the shell; each lobe identical with the others, gently convex and with a rounded margin, slightly flattened medianly; each lobe with a pair of obscure, elongated markings, slightly raised areas on the inner surface of the shell, that suggest muscle scars, one such marking on each slope of each lobe a short distance from the bordering groove, the upper end falling somewhat short of reaching the apex and the lower end removed from the margin by about a quarter the radius of the shell or less; ornamented by fine, sharp radiating striae with wide, flat interspaces within which finer striae of second and third orders are intercalated progressively away from the apex; undulating lines of growth, strongest on the convex central areas of each lobe; apex seemingly sharp, its finer details not well known; shell seemingly exceedingly thin and fragile, flexible.

*Horizon and locality.*—Trenton limestone, upper third; Trenton Falls, Oneida County, New York.

*Discussion.*—The type collection consists in all of seven specimens, all except the holotype much distorted, and two specimens torn before fossilization. In none of the specimens is the shell preserved. All consist of external and internal molds, several of which include counterparts of the same shell. The matrix is an exceedingly fine, dense black limestone of lithographic texture and very perfect conchoidal fracture. Before lithification it must have been a very fine, soft ooze with a high organic content.

Walcott in his original description quite rightly emphasizes the fragility of the shell. He wrote

> The shell was of a membraneous character. A crushed individual shows the two sides doubled at an acute angle, while a split extends nearly to the apex. The substance of the shell is not preserved in any specimens found. Associated Lamellibranchiates, and Gasteropods, *Bellerophen bilobatus*, *Bucania bidorsata*, etc., have the shelly structure preserved. [The last sentence is in a footnote.]

One specimen shows on the external mold two irregular vermiform ridges seemingly pressed in from the exterior and seemingly caused by worn-tubes adherent to the outer surface of the shell. The counterpart shows these as depressions. The sculpture of the shell is as sharply marked on the internal as on the external mold.

The holotype (M.C.Z. 27930) is the only specimen that is not obviously distorted or distorted and torn. The specimen from which the drawing figured by Ulrich and Scofield was taken (M.C.Z. 27928) is considerably distorted. The supposed muscle scars can be seen quite clearly on a number of the specimens, including the holotype and one of the specimens under number M.C.Z. 27927. They are visible in both external and internal molds of the holotype. In the internal molds, where they are best defined, they are long, depressed areas very narrow and nearly radial on the upper half of the shell and broader and curved gently toward the median line of the lobe below, the broadened portion crossed by obscure scratch-like markings, oblique outward from above.

Walcott does not record how the specimens were oriented in the rock, and it is not now possible to be certain, but what evidence there is suggests that the aperture was down. Nothing is known as to the habits of the animal. The seeming worm tubes suggest a bottom dweller, though they may have become attached after death. It is not impossible that an animal with even so fragile a shell as this may have been at home on a soft ooze, such as is suggested by the matrix, in very quiet water. On the other hand, the perfect radial symmetry without hint of front or back suggests very delicately shelled plancton or necton, the remains of which were preserved only in this exceptionally favorable medium.

The seemingly significant features of the species are the following:

1. Its low, symmetrical, conical form.
2. Its four symmetrical lobes or panels.
3. Its seeming muscle scars, eight in number and symmetrically arranged in four pairs.
4. Its seemingly very thin, fragile, almost flexible shell.

The first of these features, except for the perfect symmetry, is not incompatible with the patellid gastropods with which the species was associated by Miller and by Ulrich and Scofield, who knew the species from the literature only and especially from the only known drawing of a distorted specimen. The second and third features, involving a quadrilateral radial symmetry, are wholly unlike any true gastropod known, and are incompatible with the well-known bilateral plan of organization of any gastropod, or indeed of any mollusk.

A comparison of these features with those of *Conularia*, on the other hand, reveals a striking agreement. *Conularia* is conical or pyramidal, though the cone

is much more acute than in *Conchopeltis*. Both have quadrilateral radial symmetry; both have four panels with lobe-like marginal extensions. Some species of *Conularia* had very thin, almost flexible shells. The differences between *Conchopeltis* and *Conularia* are of the order that distinguish genera of the same family or, at most, families of the same order. The differences between *Conchopeltis* and *Conularia*, on the one hand, and the Gastropoda proper, on the other, seem to be of the order that distinguish phyla. The quadrilateral radial symmetry of *Conularia* and *Conchopeltis*, which, if the supposed muscle scars are significant, extends to the organization of the soft parts, seems to compel their exclusion from the Mollusca.

We probably know too little of the details of organization of either *Conularia* or *Conchopeltis* to know precisely what their affinities are, but if our lack of knowledge prevents us from making a definite assignment it is suggested that quadrilateral radially symmetrical forms such as these would appear to be far less out of place appended to either the class Hydrozoa or the class Scyphozoa of the Coelenterata, in the medusae of both of which there is a characteristic quadrilateral radial symmetery, than to the bilaterally symmetrical Mollusca. It does not require much imagination to visualize a branch of the Hydrozoa or perhaps of the Scyphozoa as having acquired an external shell, at first membraneous and later strengthened with calcareous matter. It is suggested that the obscure markings here tentatively regarded as muscle scars may have had some connection with the gonads, which in the Scyphozoa are four in number and horseshoe-shaped. *Conchopeltis* in its only known examples is almost contemporaneous with the earlier species of *Conularia*, and such fragile forms may well have existed long before without leaving any traces of their existence, so rare would be the conditions under which remains or delicate impressions would be preserved.

If the class Conulariida were so placed it might well include besides the Conulariidae (*Conularia* and *Conchopeltis*) the radially symmetrical Tentaculitidae. The Hyolithidae, at present included by some in the Conulariida, is a family of bilaterally symmetrical genera that are different from the Conulariidae, as here constituted, in many significant respects and seem most probably to be Mollusca —possibly operculate Pteropoda with phosphatic shells.

## REFERENCES

1. MILLER, S. A., *North American geology and paleontology*, p. 400, Cincinnati, 1889.
2. WALCOTT, C. A., Descriptions of new species of fossils from the Trenton limestone: *New York State Mus. Nat. History, 28th Ann. Rept.*, doc. ed., p. 93, Albany, 1875.
3. ULRICH, E. O., and SCHOFIELD, W. H., The Lower Silurian Gastropoda of Minnesota: *Geology of Minnesota, Final Rept.*, vol. 3, pt. 2, p. 822, Minneapolis, 1897.

NOTE: The manuscript of this paper was received by the editor May 2, 1936.

## EXPLANATION OF PLATE 29

FIGS. *1–5*—*Conchopeltis alternata* Walcott, ×9/10. *1, 2*, Internal mold of holotype; the "muscle scars" can be seen best on lobe to right. *3*, External mold of holotype. *4*, Paratype (one of the specimens under M. C. Z. no. 27927); the "muscle scars" can be seen clearly on right lobe. *5*, Paratype (one of the specimens under M. C. Z. no. 27927); internal mold of a crushed and torn specimen; shows two vermiform impressions near apex. (p. 186)

1

3

2

4

5

Knight, Ordovician Mollusk

UNIV. OF MICH.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 3, PP. 189–201, PLS. 30–32, APRIL, 1937

# THE PALEOZOIC RUGOSE CORAL FAMILY PALEOCYCLIDAE

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ABSTRACT

The Paleocyclidae, supposedly the simplest of the tetracorals, occur in the Silurian, Devonian, Mississippian and Pennsylvanian. Except for four species, they are not commonly reported. The family, as here interpreted, includes eight genera, of which one is new, and 37 species, of which 13 are new.

The small button-shaped to cushion-shaped corals comprised in the family Paleocyclidae of the Rugosa are infrequently mentioned in geologic literature. The present paper has been prepared not only to stimulate interest in these fossils but also to increase their usefulness in stratigraphic work. The European Silurian species, *Paleocyclus porpita*, and the American Devonian form, *Hadrophyllum orbignyi*, are the best known representatives of the family; indeed, they and *Microcyclus discus*, with its ally *M. thedfordensis*, are the only species occurring commonly. In the course of years a number of new species have been assembled in the collections of the United States National Museum, short descriptions and illustrations of which, as well as of all other forms of the family known to the writer, are presented in this article.[1]

[1] The excellent paper, *The British Silurian rugose corals with acanthine septa*, by Dr. Dorothy Hill (*Roy. Soc. London, Philosophical Trans.*, ser. B, no. 534, vol. 226, pp. 189–217, pls. 29, 30, Aug. 1936), in which the minute septal structure of *Paleocyclus* and related genera is described and the relation of these genera to *Tryplasma* and *Cystiphyllum* is discussed, was received too late for discussion here. A turbinate *Acanthocyclus*, *A. transiens*, n. sp., from the Wenlock shales of Malverns, England, was described.

The Paleocyclidae possess no tabulae, dissepiments, or columella, and with the Columnariidae are usually regarded as the simplest of Paleozoic Tetracoralla. This is possibly not true, as the oldest known forms are of Silurian age and the family is preceded in Ordovician time by species of *Streptelasma*, *Protarea*, and several other genera, besides the well-represented Columnariidae. The septal structure of *Paleocyclus* certainly has much resemblance to *Heliophyllum*, and similarities can be traced between other paleocycloid genera and certain cyathophylloid corals. These so-called simple corals may be derivatives of species of quite different affinities, but at any rate the discovery of more specimens may present interesting problems in evolution. The types of all the new species herein described are in the collections of the United States National Museum. Topotypes of most of the species are in the British Museum (Natural History).

## DESCRIPTION OF SPECIES

### Subclass TETRACORALLA (RUGOSA)
### Family PALEOCYCLIDAE Dybowski

Simple, discoidal to erectly turbinate (depressed, top-shaped) Paleozoic rugose

corals with major and minor septa and basal epitheca (stereozone) strongly developed but without dissepiments, tabulae, or columella. Cardinal, counter, and alar fossulae developed in various degrees, except in the earliest genera.

### Genus PALEOCYCLUS Edwards and Haime, 1849

*Paleocyclus* EDWARDS and HAIME, *1849*, Acad. sci. Paris, Comptes rendus, vol. 29, p. 70. —SHERZER, *1891*, Am. Geologist, vol. 7, p. 278.—BASSLER, *1915*, U. S. Nat. Mus., Bull. 92, p. 936 (references).—LANG and SMITH, *1927*, Geol. Soc. London, Quart. Jour., vol. 83, p. 455.

Corallum small, disk-shaped, with flat epithecated base bearing a small centrally placed cone of attachment at right angles to the disk; calyx with major and minor spinose septa radiately arranged, the major septa bearing moniliform transverse dilatations, and reaching the center; no fossulae, tabulae, or dissepiments.

Genotype: *Madrepora porpita* Linnaeus, 1767. Silurian of Gotland. *P. fletcheri* Edwards and Haime, 1851, was selected as the genotype of *Acanthocyclus*.

#### PALEOCYCLUS PORPITA (Linnaeus), 1767

Plate 30, figures 1–4

*Madrepora porpita* LINNAEUS, *1767*, Syst. Nat. ed. 12, p. 1272.

*Paleocyclus porpita* EDWARDS and HAIME, *1854*, Mon. British Foss. Corals, 1854, p. 246 (bibliography) (not pl. 77, figs. 1*a–c*. = *Acanthocyclus porpitoides*).—LANG and SMITH, Geol. Soc. London, Quart. Jour., vol. 83, p. 485, fig. 17 (synonymy).

Corallum averaging 16 mm. in width and 4 mm. in height, circular, with about 26 major septa uniformly developed, reaching to the center, and an equal number of minor septa extending only a third of this distance; both major and minor septa strongly spinose, the lateral spines or dilatations uniting to form crossbars as they near the center.

Occurrence: Silurian; Island of Gotland (Lower Gotlandian); Marloes Bay and Tortworth, England (Llandovery).

Hypotypes: U. S. Nat. Mus. 91051.

#### PALEOCYCLUS ROTULOIDES (Hall), 1852

Plate 30, figures 5, 6

*Cyclolites rotuloides* HALL, *1852*, Pal. New York, vol. 2, p. 42, pl. 17, figs. 4*a–e*.—MILLER, *1889*, North Am. Geology and Paleontology, p. 199, fig. 203.

Similar to *P. porpita* but smaller and thinner, averaging 10 mm. in width and 1 mm. in thickness, with about 20 major septa bearing nodelike spines or elevations; minor septa extend only a fourth or less of the distance to the center.

Occurrence: Silurian (Niagaran-Clinton shale); near Clinton, New York.

Hypotypes: U. S. Nat. Mus. 51167.

#### PALEOCYCLUS MICHIGANENSIS Bassler, n. sp.

Plate 30, figures 10–12

This species, averaging 10 mm. in diameter, differs from *P. rotuloides* in its more conical base, thicker epitheca, more prominent and sharply spinose but thinner major septa, of which there are about 22, and its short but equally spinose minor septa, which reach about a third of the distance to the center.

Occurrence: Silurian (Niagaran-Manistique formation); Scott quarry, 2 miles south of Cardell, Michigan.

Syntypes: U. S. Nat. Mus. 91052.

#### PALEOCYCLUS KIRBYI Meek, 1868

Plate 30, figures 7–9

*Paleocyclus kirbyi* MEEK, *1868*, Chicago Acad. Sci., Trans., vol. 1, p. 85, pl. 11, fig. 5.

This large species is known only from the original illustrations, which show a corallum much like the genotype except that it is larger (30 mm. in diameter and 6 mm. high) and has about 45 major septa extending to the shallow depressed center, with the characteristic crenulations absent or poorly developed, and minor septa very similar to the major ones, extending well towards the center.

Occurrence: Devonian; Porcupine River, Alaska, lat. 66°27′N., 143°W.

### Genus ACANTHOCYCLUS Dybowski, 1873

*Acanthocyclus* DYBOWSKI, *1873*, Arch. Natur. Liv. Ehst. Kurl., ser. 1, vol. 5, p. 103 (359).—SHERZER, *1891*, Am. Geologist, vol. 7, p. 278.—LANG and SMITH, *1927*, Geol. Soc. London, Quart. Jour., vol. 83, p. 450.—SMITH, *1930*, *idem*, vol. 86, p. 294.

Simple, discoidal to turbinate corals like *Paleocyclus*, save that the basal cone of attachment (peduncle) is excentric and directed obliquely to the corallum. Septa strongly crenulated, the major ones meeting in the cup at a point outside the center and the minor much shorter. No fossulae.

Genotype: *Paleocyclus fletcheri* Edwards and Haime, 1851. Silurian of Dudley, England.

#### ACANTHOCYCLUS FLETCHERI (Edwards and Haime), 1851
Plate 30, figures 13–15

*Paleocyclus fletcheri* EDWARDS and HAIME, *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, p. 205; *1854*, Mon. British Foss. Corals, p. 248, pl. 77, figs. 3–3*f*.

*Acanthocyclus fletcheri* LANG and SMITH, *1927*, Geol. Soc. London, Quart, Jour., vol. 83, p. 450, figs. 1, 2.

Peduncle short, well elevated, strongly curved excentrically placed, with thickened basal epitheca exhibiting well-defined concentric rings of growth; and a calyx averaging 14 mm. in width and bearing strong, denticulated major septa that meet in a point below the center; minor septa short but equally denticulated.

Occurrence: Silurian (Wenlock); Dudley, England.

Hypotype: U. S. Nat. Mus. 81372.

#### ACANTHOCYCLUS PARVULUS Bassler, n. sp.
Plate 30, figures 16–19

Corallum small, circular, about 7 mm. in diameter, with basal side marked by delicate concentric rings of epitheca, arising just outside the center into a well-elevated, rounded peduncle only slightly obliquely directed; inner half of calyx deeply excavated; about 30 major septa; minor septa extending less than half way to the center; both sets of septa with strong, closely set undulations instead of sharp denticulations. The small size combined with the relatively large number of septa will readily distinguish this species.

Occurrence: Silurian (Niagaran); Masonville, Iowa.

Syntypes: U. S. Nat. Mus. 56619.

#### ACANTHOCYCLUS CATINULUS Dybowski, 1873
Plate 30, figure 31

*Acanthocyclus catinulus* DYBOWSKI, *1873*, Arch. Natur. Liv.-Ehst. Kurl., ser. 1, vol. 5, p. 103 (359), figs. 10–10*b*.

This species and *A. fletcheri* formed the genosyntypes of *Acanthocyclus*, but Smith and Lang in 1927 selected the latter as the genolectotype. The original illustrations show *Acanthocyclus catinulus* with about 30 major septa and a diameter of about 13 mm.

Occurrence: Silurian; Moon Island, Esthonia.

#### ACANTHOCYCLUS BINUS (Lonsdale), 1839

*Turbinolopsis bina* LONSDALE, *1839*, in Murchison, Silurian System, p. 692, pl. 16 bis, figs. 5, 5*a*.

*Acanthocyclus binus* LANG and SMITH, *1927*, Geol. Soc. London, Quart. Jour., vol. 8, p. 483, pl. 37, fig. 5.—SMITH, *1930*, *idem*., vol. 86, p. 294.

For a discussion of this species and the related although doubtful *Turbinolopsis elongata* Phillips, the student is referred to the work of Lang and Smith cited above. Better material of both species is necessary before their characteristics are known.

Occurrence: Silurian (Upper Llandovery); Marloes Bay, Pembrokeshire, England.

#### ACANTHOCYCLUS PORPITOIDES Lang and Smith, 1927
Plate 30, figures 20–23

*Paleocyclus porpita* EDWARDS and HAIME (not Linnaeus), *1854*, Mon. British Foss. Corals, pl. 57, figs. 1*a–c*.

*Acanthocyclus porpitoides* LANG and SMITH, *1927*, Geol. Soc. London, Quart. Jour., vol. 83, pt. 3, p. 486.

The corallum in this species, about 12 mm. in width and with 30 major septa, is very similar to *Paleocyclus porpita* but may be readily distinguished by the excentric position of the cone of attachment (peduncle), which is also directed obliquely to the corallum.

Occurrence: Silurian (Wenlock); Dudley, England.

Hypotype: U. S. Nat. Mus. 92083.

ACANTHOCYCLUS MAGNUS Bassler, n. sp.
Plate 30, figure 27

Corallum large, irregularly discoidal, 25 mm. in diameter, with calyx depressed and exhibiting about 32 sharp, strongly developed major septa meeting at a point just beyond the center, widely separated and strongly denticulated; minor septa

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EXPLANATION OF PLATE 30

FIGS. *1–4—Paleocyclus porpita* (Linnaeus), 1767. *1*, Calyx of flat discoidal corallum showing alternate long and short septa with pronounced crenulations; *2*, concentrically wrinkled epitheca with flat central peduncle; *3*, edge view; all ×1½. *4*, enlargement of figure *1* (×4) showing septal structure in more detail. Silurian (Lower Gotlandian): Island of Gotland. (p. 190)

*5, 6—Paleocyclus rotuloides* (Hall), 1852. Upper side of small specimen and epithecal side af larger specimen, both ×2, the latter worn and showing base of septa. Niagaran (Clinton shale): Clinton, New York. (p. 190)

*7–9—Paleocyclus kirbyi* Meek, 1868. Copies of the original figures, ×1, of this large species, which has not been rediscovered. Devonian: Porcupine River, Alaska (lat. 66°, long. 143°). (p. 190)

*10–12—Paleocyclus michiganensis* Bassler, n. sp. *10*, The two types embedded in shaly limestone, ×1½; *11*, part of the smaller one, ×4½, showing the strong crenulations; *12*, basal side of a free specimen showing the central point of attachment, ×1½. Silurian (Niagaran-Manistique formation): Scott Quarry, 2 miles south of Cardell, Michigan. (p. 190)

*13–15—Acanthocyclus fletcheri* (Edwards and Haime), 1851. Cup of specimen exhibiting arrangement of the strongly crenulated septa; and basal and side views showing the subcentral strongly curved elevated peduncle; all ×1½. Silurian (Wenlock): Dudley, England. (p. 191)

*16–19—Acanthocyclus parvulus* Bassler, n. sp. *16*, Small circular corallum; *17*, edge view of same; both ×1½. *18*, Basal view, ×2, showing the excentrically placed conspicuous peduncle. *19*, Enlarged view of another cup with excavated center, ×4, illustrating the strongly crenulated major and minor septa. Niagaran: Masonville, Iowa. (p. 191)

*20–23—Acanthocyclus porpitoides* Lang and Smith, 1927. *20*, View of cup, ×1½; *21*, portion of same, ×4, showing resemblance to *Paleocyclus porpita*. *22*, *23* Basal view of corallum and edge view, both ×1½, illustrating excentric position of peduncle characteristic of *Acanthocyclus*. Silurian (Wenlock): Dudley, England. (p. 191)

*24, 25—Acanthocyclus iowensis* Bassler, n. sp. Type specimen preserved in chert with septa occurring as cavities, and basal view of same showing the excentric peduncle, both ×1½. Niagaran (Hopkinton dolomite): Monticello, Iowa. (p. 193)

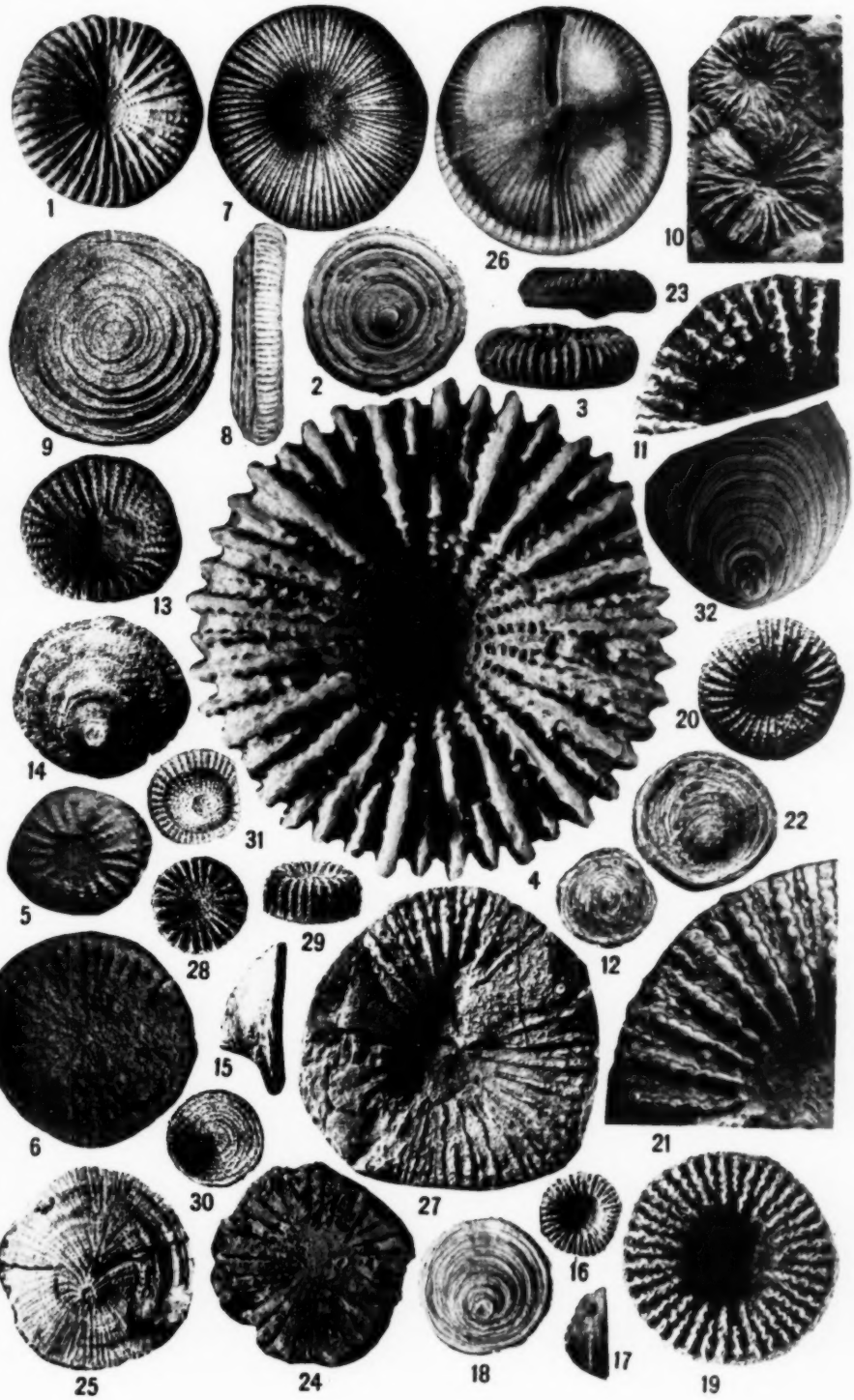
*26—Microcyclus? arenarius* (Meek and Worthen), 1868. The original view of this species, natural size, which has not been rediscovered. Devonian (Onondaga-Dutch Creek sandstone): 4 miles west of Jonesboro, Union County, Illinois. (p. 195)

*27—Acanthocyclus magnus* Bassler, n. sp. Type specimen, ×1½, showing its large proportions. Silurian (LaVieille limestone): Quinn's Point, 3 miles east of Jacquet River, New Brunswick.

*28–30—Microcyclus? praecox* (Roemer), 1844. Roemer's views of this well-developed species, natural size. Devonian (Calceola beds): Bigge, Germany. (p. 195)

*31—Acanthocyclus catinulus* Dybowski, 1873. Calyx, natural size (after Dybowski). Silurian: Moon Island, Esthonia. (p. 191)

*32—Hadrophyllum linguloideum* Herzer, 1901. Basal side of corallum, natural size, illustrating lateral position of center of growth. Devonian (Onondaga-Jeffersonville limestone): Falls of the Ohio. (p. 197)




Bassler, Paleozoic Corals

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similarly marked but proceeding only a short distance into the cup.

The large corallum and the strong development of its various characters make this species easy of recognition.

Occurrence: Silurian (LaVieille limestone); Quinn's Point, 3 miles east of Jacquet River, New Brunswick.

Holotype: U. S. Nat. Mus. 93188.

ACANTHOCYCLUS IOWENSIS
Bassler, n. sp.
Plate 30, figures 24, 25

The type specimen, found adhering by its upper side to a block of chert, represents a species so different that it is here described as new. Its diameter is about 18 mm. and the thickness 3 mm., with the thin, circular corallum exhibiting a small, low peduncular point of attachment just a short distance beyond the center of the base, which is lined with concentric rays of epitheca. The calyx, after the removal of the chert, exhibits about (30 major septa) with well crenulated walls and a corresponding minor set much less developed. The thinness of the corallum with its slightly elevated peduncle, as well as the arrangement of the septa and the absence of fossulae, distinguish this species.

Occurrence: Silurian (Niagaran-Hopkinton dolomite); Monticello, Iowa.

Holotype: U. S. Nat. Mus. 50215.

## Genus MICROCYCLUS Meek and Worthen, 1868

*Microcyclus* MEEK and WORTHEN, *1868*, Illinois Geol. Survey., vol. 3, p. 420.—NICHOLSON, *1874*, Paleontology Province of Ontario, pt. 1, p. 38.—MILLER, *1889*, North Am. Geology and Paleontology, p. 196.—SHERZER, *1891*, Am. Geologist, vol. 7, p. 278.—LAMBE, *1901*, Canada Geol. Survey, vol. 4, pt. 2, p. 106.

Thin, discoidal, almost flat free coralla with a small central irregular basal scar of attachment and a shallow calyx provided with smooth septa arranged in four groups separated by fossulae of which the cardinal one, with a conspicuous cardinal septum, is best developed. Major septa merging into a smooth central area; minor septa short and often attached to the major. The smooth septa and conspicuous cardinal fossula with its cardinal septum are characteristic of *Microcyclus*, which represents the stage of development in the family at which all the fossulae but the cardinal one are inconspicuous.

Goldfuss (*Petrefacta Germaniae*, p. 48, pl. 14, figs. 3a, b), describes and illustrates as *Fungia clypeata* n. sp., from an unknown locality, a species of *Microcyclus* which must be restudied and added to this list.

Genotype: *M. discus* Meek and Worthen, 1868. Devonian of Illinois.

MICROCYCLUS DISCUS Meek and Worthen, 1868
Plate 31, figures 1–4

*Microcyclus discus* MEEK and WORTHEN, *1868* Illinois Geol. Survey, vol. 3, p. 420, pl. 11, figs. *7a, b.*

Corallum of thin, circular, flattened disks averaging 15 mm. in diameter, with base covered by a concentrically wrinkled epitheca and a slightly convex calyx bearing a well marked cardinal fossula with a cardinal septum and inconspicuous counter and alar fossulae. About 24 narrow but smooth-edged major septa extend about two-thirds of the way to the slightly depressed center of the calyx, where they merge into a smooth region; minor septa short, usually united to the major ones.

The comparatively wide, smooth central area and short major and minor septa characterize this species, which has long been confused with the more common form from Ontario here described as *M. thedfordensis.*

Occurrence: Devonian (probably Hamilton); Backbone Ridge, Grand Tower, Illinois.

Hypotype: U. S. Nat. Mus. 91055.

MICROCYCLUS THEDFORDENSIS
Bassler, n. sp.
Plate 31, figures 5–9

*Microcyclus discus* NICHOLSON, *1874*, (not Meek and Worthen, 1868), Paleontology of Province of Ontario, pt. 1, p. 38, fig. 9.—MILLER, *1889*, North Am. Geology and Paleontology, p. 196, fig. 194.—LAMBE, *1901*, Canada Geol. Survey, vol. 4, pt. 2, p. 107.

This species, usually misidentified in collections as *M. discus*, is distinguished from that form by the following characteristics: Central smooth area is much smaller; major septa extend nearer to the center; minor septa are usually more distinct and shorter, seldom being united with the major ones; cardinal

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EXPLANATION OF PLATE 31

FIGS. *1–4*—*Microcyclus discus* Meek and Worthen, 1868. Top, edge, and basal views of well-preserved topotype, and another specimen showing calyx with smooth center, all ×1½. Devonian (probably Hamilton): Grand Tower, Illinois. (p. 193)

*5–9*—*Microcyclus thedfordensis* Bassler, n. sp. *5*, *6*, Upper and edge views showing septa extending well toward center; *7*, basal side illustrating growth upon some foreign object; *8*, specimen with cardinal and alar fossulae plainly visible; *9*, specimen with cardinal fossula and center of corallum well developed; all ×2. Devonian (Hamilton-Arkona beds): Thedford, Ontario. (p. 194)

*10–13*—*Microcyclus lyrulatus* Bassler, n. sp. Two specimens, ×2, showing prominent lyre-shaped cardinal fossula; and basal and edge views of another specimen; ×1½. Devonian (Skaneateles shale-base of Mottville member): Bear Mountain Ravine, Tully Quadrangle, Onondaga County, New York. (p. 195)

*14–16*—*Microcyclus intermedius* Bassler, n. sp. *14*, *15*, Views of gutta-percha impressions of calyx and lower sides of two specimens, ×1½; *16*, gutta-percha impression, ×1½, of specimen with all four fossulae fairly well developed and the smooth central zone plainly evident. Devonian (lower Hamilton shale): one third of a mile west of Green Spring, Virginia (*14*, *15*); and half a mile south of Cedar Grove, Frederick County, Virginia (*16*). (p. 195)

*17*—*Microcyclus blairi* Miller, 1894. The original figure of this small species, ×1½. Mississippian (Chouteau limestone) Sedalia, Missouri. (p. 196)

*18*—*Microcyclus leonensis* (Verneuil and Haime), 1850. Original view of this well-developed species, ×2. Devonian: Peña de LaVenera (Léon), Spain. (p. 195)

*19–22*—*Xenocyathellus thedfordensis* (Stewart), 1936. *19–21*, Front, lateral, and basal views of this curious species; *22*, view of another specimen looking directly into the cup; all ×2. Devonian (Hamilton-Arkona beds): Dam, Aux Sables River, mouth of Rock Glen, Arkona, Ontario. (p. 197)

*23–24*—*Microcyclus? multiradiatus* (Meek), 1868. Type specimen, ×1½, a worn disk. Middle Devonian: Onion River, British America (lat. 67°, long 125°). (p. 195)

*25–30*—*Hadrophyllum orbignyi* Edwards and Haime, 1851. *25–27*, Calyces showing variations in development of fossulae; *28*, *29*, edge views of two of these specimens; *30*, basal view of a smaller specimen, all ×1½. Devonian (Hamilton-Delaware limestone): Falls of the Ohio, vicinity of Louisville, Kentucky. (p. 197)

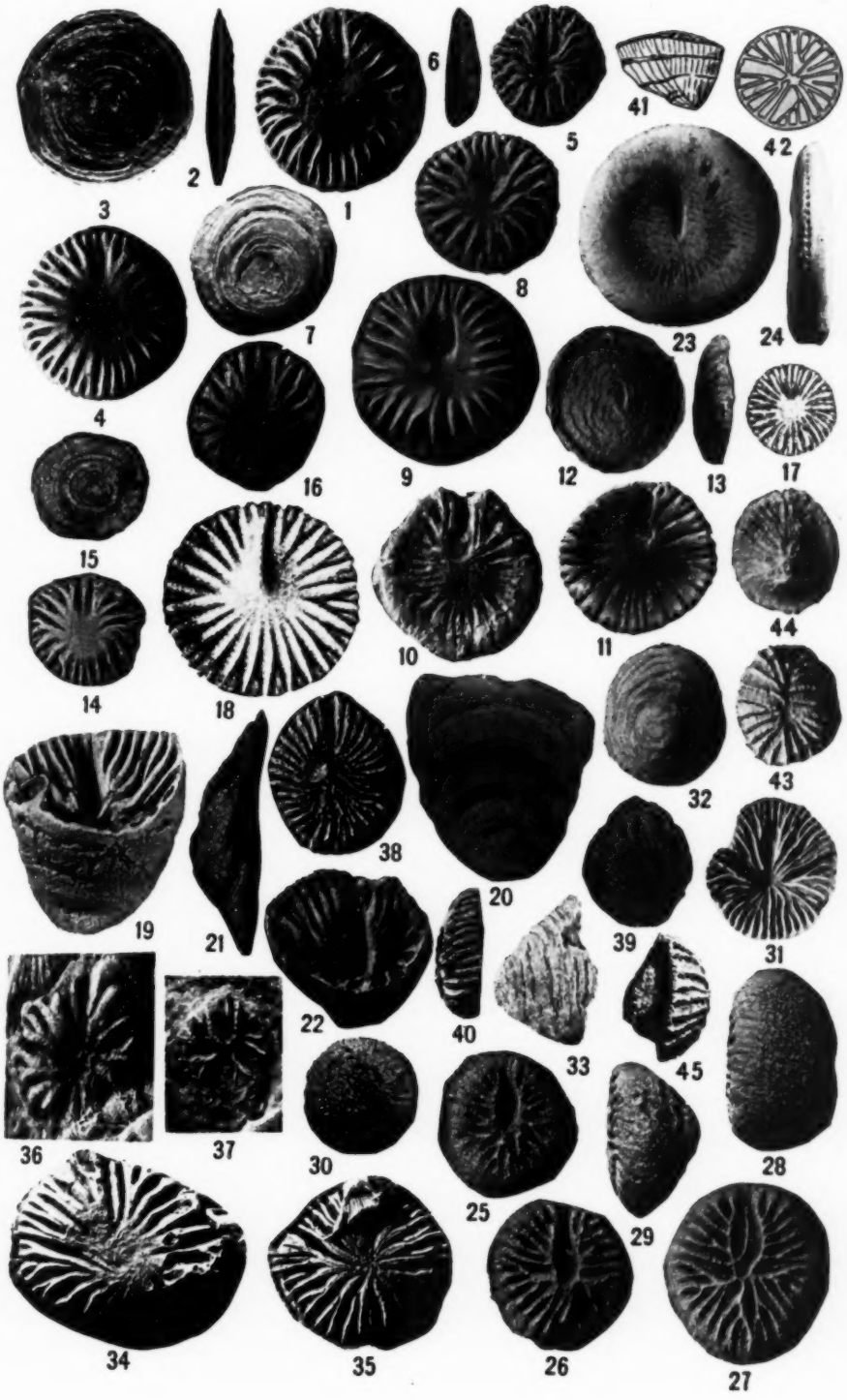
*31–33*—*Hadrophyllum pauciradiatum* Edwards and Haime, 1851. Top, basal, and side views of well-preserved corallum, ×1½, illustrating the expanded cone shape, the thin straight major and minor septa, and the four fossulae. Devonian: Eifel, Germany. (p. 198)

*34–37*—*Hadrophyllum bifidum* Bassler, n. sp. *34*, *35*, Gutta-percha impressions of two coralla showing the major septa extending to the center, and the short minor septa, ×1½; *36*, *37*, young specimens associated with the types, ×4, showing two stages in development of septa and fossulae. Devonian (lower Hamilton shale): 0.3 mile west of Green Spring, Virginia. (p. 198)

*38–40*—*Hadrophyllum delicatum* Bassler, n. sp. Top view (×2) and basal and side views (×1½) of type, showing the delicate septa with only the cardinal fossula well developed. Mississippian (St. Louis limestone): Round House Hill, Elizabethtown, Kentucky. (p. 199)

*41*, *42*—*Hadrophyllum? woodi* Grabau, 1899. Original views of the species, natural size. Devonian (Moscow shale): Eighteen Mile Creek, New York. (p. 198)

*43–45*—*Hadrophyllum nauvooense* Bassler, n. sp. Top, basal, and side views of type, ×1½, a small robust specimen with convex calyx and well-defined peduncle. Mississippian (Keokuk formation): Near Nauvoo, Illinois. (p. 199)




Bassler, Paleozoic Corals

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fossula is deeper and more pronounced, with septum more distinct. A corallum averages about 10 mm. in diameter and bears about 22 major septa.

Occurrence: Devonian (Hamilton-Arkona beds); Thedford and Arkona, Ontario.

Syntypes: U. S. Nat. Mus. 26611.

### MICROCYCLUS? MULTIRADIATUS (Meek), 1868
Plate 31, figures 23, 24

*Combophyllum multiradiatum* MEEK, *1868*, Chicago Acad. Sci., Trans., vol. 1, p. 84, pl. 11, fig. 4.

The type, a circular disk 18 mm. wide and about 3 mm. thick, very much worn, indicates that this species belongs to *Microcyclus*, although better preserved material is necessary to establish its full specific characters.

Occurrence: Middle Devonian; Onion River, British America, lat. 67°, long. 125°.

Holotype: U. S. Nat. Mus. 14952.

### MICROCYCLUS LYRULATUS Bassler, n. sp.
Plate 31, figures 10–13

Corallum small, averaging 10 mm. in diameter and less than 2 mm. thick, with slightly concave calyx and convex base. Cardinal fossula well developed, with the two slightly curved outlining major septa forming a lyre-shaped area. Major septa 18 to 20 in number extending about two-thirds the distance to the center, the minor septa so united with them as to appear like smooth broad bands.

Occurrence: Devonian (Skaneateles shale—base of Mottville member); Bear Mountain Ravine, Tully quadrangle, Onondaga County, New York.

Syntypes: U. S. Nat. Mus. 91053.

### MICROCYCLUS INTERMEDIUS Bassler, n. sp.
Plate 31, figures 14–16

In this species the corallum is discoid, about 12 mm. wide but more elevated than usual, being 3 to 4 mm. high. About 20 major septa with the minor septa united as in the genotype are present, but the alar and counter fossulae are more clearly developed. The species may thus be said to be intermediate between *Microcyclus* and *Hadrophyllum*.

Occurrence: Devonian (Lower Hamilton shale); half a mile south of Cedar Grove, Frederick County, Virginia.

Syntypes: U. S. Nat. Mus. 91054.

### MICROCYCLUS? ARENARIUS (Meek and Worthen), 1868
Plate 30, figure 26

*Baryphyllum? arenarium* MEEK and WORTHEN, *1868*, Illinois Geol. Survey, vol. 3, p. 409, pl. 9, figs. 2*a*, *b*.

Additional material is necessary before the position and characteristics of this species can be determined, but the type specimen is probably a large *Microcyclus* characterized by a deep narrow cardinal fossula and a large number of major septa extending well towards the center.

Occurrence: Devonian (Onondaga-Dutch Creek sandstone); 4 miles west of Jonesboro, Union County, Illinois.

### MICROCYCLUS LEONENSIS (Verneuil and Haime), 1850
Plate 31, figure 18

*Discophyllum leonense* VERNEUIL and HAIME. *1850*, Soc. géol. France, Bull., ser. 2, vol. 7, p. 161.

*Combophyllum leonense* EDWARDS and HAIME, *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, p. 359, pl. 6, figs. 6, 6*a*.

The original illustration shows this to be a *Microcyclus* about 12 mm. in diameter and 2 or 3 mm. thick, with the cardinal fossula well developed and about 26 major septa merging towards the center into a smooth area and separated around the circumference by short but well defined minor septa.

Occurrence: Devonian; Peña de la Venera (Léon), Spain.

### MICROCYCLUS? PRAECOX (Ferd. Roemer), 1844
Plate 30, figures 28–30

*Fungia praecox* FERD. ROEMER, *1844*, Rheinische Uebergangsgebirge, p. 58, pl. 3, fig. 1.

*Combophyllum praecox* EDWARDS and HAIME, *1851*, Mono. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, p. 360 (gen. ref.).

Roemer's illustrations indicate that this is probably a highly convex *Microcyclus* about 10 mm. wide and 5 mm. high, in which the fossulae are quite inconspicuous or absent, the depressed smooth central area small, and the major septa, about 22 in number, very regularly arranged. *Microcyclus eifelensis* Kayser, 1892, may be based upon this same species.

Occurrence: Devonian (Calceola beds); Bigge, Germany.

MICROCYCLUS BLAIRI Miller, 1894
Plate 31, figure 17

*Microcyclus blairi* MILLER, *1894*, Indiana Dept. Geol. and Nat. Res., 18th Rept., p. 261, pl. 9, figs. 27, 28 (adv. sheets, 1892, p. 7, pl. 9, figs. 27, 28); *1892*, North Am. Geology and Paleontology, 1st app., p. 669, fig. 1201.—KEYES, *1894*, Missouri Geol. Survey, vol. 4, p. 117.

Judging from the original illustration, this species appears to be a *Microcyclus* about 8 mm. wide with probably 24 major septa radiating regularly from a small, smooth central area and separated by short minor septa, but with all of the fossulae inconspicuous.

Occurrence: Mississippian (Chouteau limestone); Sedalia, Missouri.

Genus COMBOPHYLLUM Edwards and Haime, 1850

*Combophyllum* EDWARDS and HAIME, *1850*, British Foss. Corals, p. lxvii; *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat. vol. 5, pp. 167, 359.—DYBOWSKI, *1873*, Arch. Natur. Liv.-Ehst. Kurl., vol. 5, p. 334.—SHERZER, *1891*, Am. Geologist, vol. 7, p. 278.

Judging from the original illustrations, this genus has the calyx structure of *Microcyclus*, notably a pronounced cardinal fossula and inconspicuous counter and alar fossulae, but differs in that the epithecated base is reduced to a very small area of attachment, the septa appearing on the under side not covered by epitheca and extending almost to the center. It is possible that the illustrations are diagrammatic and the original specimen was worn so as to show the base of the septa through the epitheca. However, as figured, the genus appears to bear the same relation to *Microcyclus* that *Baryphyllum* does to *Hadrophyllum*.

Genotype: *C. osismorum* Edwards and Haime, 1851. Devonian of France. *Combophyllum multiradiatum* Meek, 1868, is here referred doubtfully to *Microcyclus*.

COMBOPHYLLUM OSISMORUM Edwards and Haime, 1851
Plate 32, figures 26–28

*Combophyllum osismorum* EDWARDS and HAIME, *1851*, Mono. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, p. 359, pl. 2, figs. 2, 2*a–c*.

This interesting species, if correctly figured, indicates a well-marked stage in the development of the Paleocyclidae. The type has a diameter of about 8 mm., a thickness of 2 mm., and about 22 major septa, which at least on the basal side of the corallum appear minutely crenulated.

Occurrence: Lower Devonian; Brest, France.

Genus XENOCYATHELLUS Bassler, n. gen.

Corallum flattened, slipper shape (calceoloid), attached to some shell or other object beyond which it grows prone upon the bottom, acuminate at the base giving a subtriangular outline; basal side almost flat and opposite side low convex, each with strongly wrinkled epitheca; calyx opening on the broad half of the upper side at such an angle that the alar and counter fossulae are hidden by the edge of the cup, leaving the deep, well developed cardinal fossula quite visible to the center. Counter half of cup very narrow, much compressed, the counter fossula being much shortened. Septa arranged in four groups, one on each side of the counter fossula consisting of three very short major septa, and a group to the right and one to the left of the cardinal fossula very much larger, with each containing seven major septa. Minor

septa when developed at all, united with the major. *Homalophyllum* Simpson, 1902 (genotype, *Zaphrentis ungula* Rominger, 1876) has a similar form but quite different arrangement of the septa.

Genotype: *Homalophyllum thedfordensis* Stewart, 1936. Middle Devonian of Ontario.

XENOCYATHELLUS THEDFORDENSIS (Stewart), 1936
Plate 31, figures 19–22

*Homalophyllum thedfordensis* STEWART, *1936*, Am. Midland Naturalist, vol. 17, no. 5, p. 878, figs. 1–4.

This interesting species described above in the generic diagnosis is represented by about 40 specimens collected and presented to the National Museum by Charles Southworth of Thedford, Ontario. All of these specimens show the same curious growth form so that what appeared as a malformed condition is evidently a constant character. The narrowness of the area on each side of the counter fossula and the great width of the opposite part of the calyx, as well as the slipper shape, make this form easily recognized. An average corallum is 15 mm. long and 12 mm. across the expanded part of the cup.

Occurrence: Devonian (Hamilton-Arkona beds); Arkona and Thedford, Ontario.

Hypotypes: U. S. Nat. Mus. 91064.

## Genus HADROPHYLLUM Edwards and Haime, 1850

*Hadrophyllum* EDWARDS and HAIME, *1850*, British Foss. Corals, p. lxvii, pl. 17; *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, pp. 166, 357.—DE KONINCK, *1872*, Acad. royale Belgique, Mém., vol. 39, p. 51.—DYBOWSKI, *1873*, Arch. Natur. Liv.-Ehst. Kurl., vol. 5, p. 333.—MILLER, *1889*, North Am. Geology and Paleontology, p. 191.—SHERZER, *1891*, Am. Geologist, vol. 7, p. 278.—GRABAU, *1899*, Buffalo Soc. Nat. Sci., Bull., p. 128.

Cushion- or top-shaped, short thick coralla, with calyx restricted to convex upper surface and side and base covered by thick epitheca and extended into a peduncle terminating sharply or bluntly beyond the center, opposite the counter fossula. The calyx shows a broad excavated cardinal fossula, a distinct but narrow counter fossula, and two less conspicuous alars, all of which delimit four groups of smooth major septa with several of each group united to the one outlining the fossula. Minor septa short, usually united with the major; cardinal and counter septa well developed. The thick elevated corallum with the calyx presenting four well developed fossulae and the base a conspicuous peduncle of attachment, characterizes this genus.

Genotype: *H. orbignyi* Edwards and Haime, 1851. Devonian of Indiana and Kentucky.

HADROPHYLLUM ORBIGNYI Edwards and Haime, 1851
Plate 31, figures 25–30

*Hadrophyllum orbignyi* EDWARDS and HAIME, *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Nat. Hist., vol. 5, p. 357, pl. 6, figs. 4, 4*a*.—DAVIS, *1885*, Kentucky Geol. Survey, pt. 2, pl. 103, figs. 3–11.

This very abundant species, probably the best known of the whole family, is easily recognized by its solid cushion-shaped corallum averaging 15 mm. wide and 8 mm. high, surmounted by a calyx with flat surface on which the cross arrangement of the fossulae is conspicuously developed. Variations in shape and calyx structure are numerous, a few of which are here illustrated.

Occurrence: Devonian (Hamilton-Delaware limestone); Charleston, Indiana; Falls of the Ohio at Louisville, Kentucky, and Oldham County, Kentucky.

Hypotypes: U. S. Nat. Mus. 52905.

HADROPHYLLUM LINGULOIDEUM Herzer, 1901
Plate 30, figure 32

*Hadrophyllum linguloideum* HERZER, *1901*, Ohio Acad. Sci., 10th Ann. Rept., p. 53, pl. 7, fig. 11.

This species, with a corallum often 40 mm. long and 30 mm. wide, the largest

known of the genus, is easily recognized by the *Lingula*-like aspect of the base caused by the formation of the epitheca, ring after ring, about a center of growth near the edge. The available material is too imperfectly preserved to show the calyx structure clearly, but there are apparently about 50 septa divided into four groups by the cardinal, two alars and counter fossulae, the last not plainly developed.

Occurrence: Devonian (Onondaga-Jeffersonville limestone); Falls of the Ohio, Louisville, Kentucky.

Hypotype: U. S. Nat. Mus. 37263.

HADROPHYLLUM PAUCIRADIATUM
Edwards and Haime, 1851
Plate 31, figures 31–33

*Hadrophyllum pauciradiatum* EDWARDS and HAIME, *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, p. 358, pl. 6, figs. 5, 5*a*.

The corallum in this species is that of a short, widely expanded cyathophylloid coral, but the calyx shows an arrangement of four fossulae and major and minor septa as in typical *Hadrophyllum*, with the exception that the septa are longer, narrower, and sharper, and reach to the center; dissepiments and tabulae seem to be absent, thus causing its present family classification. The calyx of a typical example is 12 mm. in diameter and contains about 24 major septa.

Occurrence: Devonian; Eifel, Germany.

Hypotypes: U. S. Nat. Mus. 56620.

HADROPHYLLUM BIFIDUM Bassler, n. sp.
Plate 31, figures 34–37

Corallum of elevated bun-shaped masses, about 15 mm. wide, occurring as molds in shale, guttapercha squeezes of which show a basal and a calyx structure characteristic of the genus. In mature specimens the four fossulae, although visible, are not so well marked because the major septa extend almost to the center and the minor septa, often united with them, reach half of this distance. However, associated young specimens, presumably of this species in which the septa had not reached their full development clearly exhibit the fossular structure of *Hadrophyllum*.

Occurrence: Devonian (lower Hamilton shale); 3 miles west of Green Spring, Virginia.

Syntypes: U. S. Nat. Mus. 91056.

HADROPHYLLUM? WOODI Grabau, 1899
Plate 31, figures 41, 42

*Hadrophyllum woodi* GRABAU, *1899*, Buffalo Soc. Nat. Sci., Bull., vol. 6, p. 128, fig. 10.

The original figures show this to be a small, stout coral, 14 mm. wide and 10 mm. high with the characteristic four fossulae of *Hadrophyllum*, but further study, particularly as to internal structure, must be finished before the exact generic determination can be known.

Occurrence: Devonian (Hamilton-Moscow shale); Eighteenmile Creek and Morse Creek, New York.

HADROPHYLLUM OVALE Bassler, n. sp.
Plate 32, figures 9–11

Corallum of oval, depressed masses about 16 mm. by 12 mm. and 6 mm. high, with the septa arranged as in the genus but extending over the sides to the edge of the flattened base on which the point of attachment is marked by a subcentral, slight elevation. Minor septa few, shown best along the edges, some uniting with the major septa, of which there are usually 24 extending nearly to the center. The four fossulae, although evident, are not sharply marked, much resembling the interseptal spaces.

The oval symmetrical form of the corallum and the diminished basal part are characteristic of this species.

Occurrence: Mississippian (Fort Payne chert); near Florence, Alabama, and Barren County, Kentucky.

Syntypes: U. S. Nat. Mus. 91059.

HADROPHYLLUM ROMINGERI
Bassler, n. sp.
Plate 32, figures 15–18

This well-marked species, named in honor of Dr. Carl Rominger, eminent student of American Paleozoic corals, is characterized by its strong, deep cardinal fossula containing a sharply elevated cardinal septum and by the fewer than usual (20) well marked, distinctly separated, major septa extending about two-thirds the distance to the center with a development of very few minor septa. An average corallum is 20 mm. long and 10 mm. high, with the base covered by a strongly concentrically wrinkled epitheca and a subcentral, well elevated peduncle. All four fossulae are plainly visible and the counter contains a septum even larger than the cardinal septum.

Occurrence: Mississippian (New Providence shale); Button Mold Knob, 12 miles south Louisville, Kentucky.

Syntypes: U. S. Nat. Mus. No. 91061.

HADROPHYLLUM TENNESSEENSE
Miller and Gurley, 1895
Plate 32, figures 12–14

*Hadrophyllum tennesseense* MILLER and GURLEY, *1895*, Illinois Mus. Nat. History, no. 7, p. 87, pl. 5, figs. 16–19.

This rather small but very robust species, averaging 16 mm. long, 14 mm. wide and 10 mm. high, has the septa and fossulae arranged as in the genus. It is without unusual features, save that the cardinal septum and cardinal fossula are extremely well developed and all major septa extend practically to the center. The base consists of a widely expanded cone ending in a rounded extremity curved below the center and ending opposite the counter septum. About 28 major septa with a few minor septa join those next to the fossulae.

Occurrence: Mississippian (Fort Payne chert); Lincoln County, Tennessee; near Florence, Alabama.

Hypotypes: U. S. Nat. Mus. 50854.

HADROPHYLLUM DELICATUM Bassler, n. sp.
Plate 31, figures 38–40

The type specimen, a silicified example about 11 mm. by 9 mm. and 3 mm. high, represents a species with a flat base bearing an inconspicuous small subcentral peduncle and with a calyx of 36 thin delicate major septa arising from the basal edge and proceeding over the sides to the center, developing a distinct cardinal fossula but indistinct counter and alar fossulae. Minor septa inconspicuous if present at all.

The delicacy of the calyx and the large number of thin, sharp-edged major septa will readily separate this species.

Occurrence: Mississippian (St. Louis limestone); Round House Hill, Elizabethtown, Kentucky.

Holotype: U. S. Nat. Mus. 91060.

HADROPHYLLUM NAUVOOENSE
Bassler, n. sp.
Plate 31, figures 43–45

Corallum about 12 mm. by 10 mm. across the calyx and 8 mm. high, with a well-elevated base ending in a subcentrally placed peduncle and a convex calyx displaying about 20 major septa converging at the center, and with the four fossulae, although quite visible, not so distinctly marked. The corallum is much as in *H. tennesseense*, differing in its smaller size, fewer septa, and less conspicuous fossulae.

Occurrence: Mississippian (Keokuk formation); near Nauvoo, Illinois.

Holotype: U. S. Nat. Mus. 42914.

HADROPHYLLUM PEDUNCULATUM
Bassler, n. sp.
Plate 32, figures 5–8

Corallum broadly oval, an average example 10 mm. high and with calyx 22 by 17 mm., with the base bearing a low but sharply elevated elongated peduncle terminating close to the edge bearing the counter fossula. Calyx flat or slightly depressed on top and vertical on the sides where the edges of the septa are visible. Major septa 20 in number, reaching the center, with a few minor septa developed mainly in the vicinity of the fossulae. Cardinal septum and fossula well developed, the other fossulae not so distinctly marked.

Occurrence: Mississippian (Fort Payne chert); 2 miles north of Nobob, Barren County, Kentucky, and Whites Creek Springs, and near Ridgetop, Tennessee.

Syntypes: U. S. Nat. Mus. 91057.

HADROPHYLLUM APLATUM
Cummins, 1891
Plate 32, figures 19, 20

*Hadrophyllum aplatum* CUMMINS, *1891*, Texas Geol. Survey, 2d Ann. Rept., p. 552, figs. 60, 61.

Apparently closely related to *H. romingeri* in the deep cardinal fossula and the few but stout septa, this species can be distinguished by the development of its base into an elevated peduncle. An average corallum is 26 mm. wide and 7 mm. high with about 24 major septa.

Occurrence: Bend division of Carboniferous; Texas.

Genus DIPTEROPHYLLUM Roemer, 1883

*Dipterophyllum* ROEMER, *1883*, Lethaea geognostica, pt. 1, Leth. Pal., p. 372.

More species of this type are necessary before the validity of *Dipterophyllum* can be proved, since its structure differs from *Hadrophyllum* only in that the peduncular point of attachment is much lengthened giving the corallum the aspect of a cup coral, and the cardinal fossula is deeply incised with the alars and counter fossulae not well developed. The arrangement of the major septa and their union with the short minor septa are precisely the same as in *Hadrophyllum*.

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EXPLANATION OF PLATE 32

FIGS. *1–4—Dipterophyllum glans* (White), 1862. *1–3*, Top, side, and basal views of typical corallum with its sharply drawn-out peduncle, ×1½; *4*, slightly weathered calyx of another specimen, ×4, showing the four fossulae and arrangement of the major and minor septa more distinctly. Mississippian (upper Burlington limestone): Burlington, Iowa. (p. 201)

*5–8—Hadrophyllum pedunculatum* Bassler, n. sp. *5*, Calyx of a silicified specimen imperfectly preserved; *6*, *7*, side and basal views of specimen showing the narrow, pointed peduncle overarching the edge of the corallum; *8*, specimen with the four fossulae and septal arrangement more apparent; all ×1½. Mississippian (Fort Payne chert): 2 miles north of Nobob, Barren County, Kentucky (p. 199)

*9–11—Hadrophyllum ovale* Bassler n. sp. *9*, Basal view of specimen showing depressed peduncle subcentrally located; *10*, calyx of specimen with arrangement of septa well shown; *11*, side view; all ×1½. Mississippian (Fort Payne chert): Near Florence, Alabama. (p. 198)

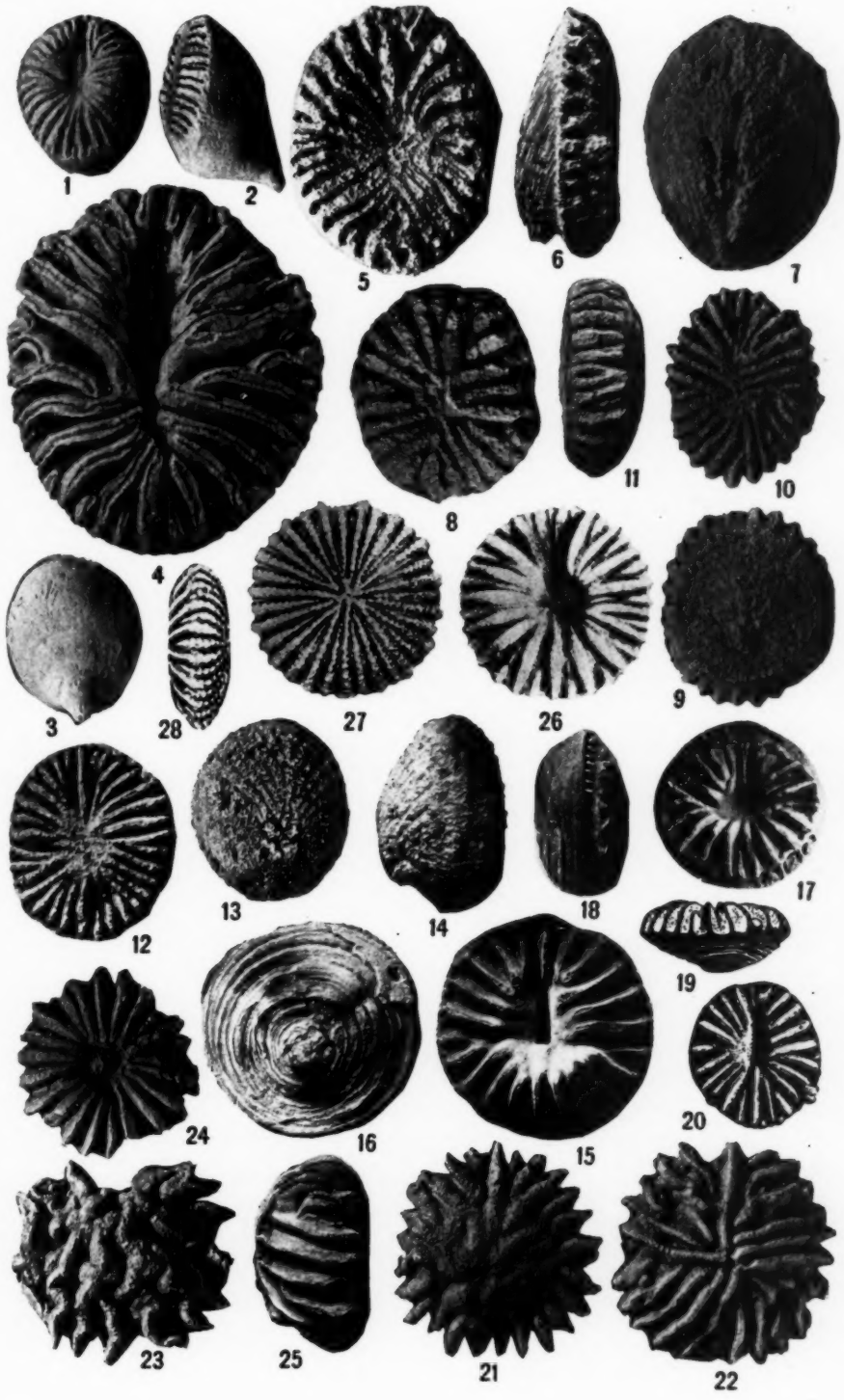
*12–14—Hadrophyllum tennesseense* Miller and Gurley, 1895. Top, basal, and side views of a silicified although well-preserved example, ×1½, exhibiting the broadly conical corallum with large peduncle. Mississippian (Fort Payne chert): Near Florence, Alabama. (p. 199)

*15–18—Hadrophyllum romingeri* Bassler, n. sp. *15*, *16*, Cup and base of syntype, showing fossular arrangement and the few robust septa; *17*, *18*, calyx and side of smaller, relatively thicker syntype; all ×1½. Mississippian (New Providence shale): Button Mold Knob, 12 miles south of Louisville, Kentucky. (p. 198)

*19, 20—Hadrophyllum aplatum* Cummins, 1891. Side and calyx views of one of the types, natural size, showing resemblance to the preceding species (after Cummins). Bend division of Carboniferous: Texas. (p. 200)

*21–25—Baryphyllum verneuillianum* Edwards and Haime, 1851. *21*, Upper side of specimen with greatly thickened septa; *22*, view of another specimen with arrangement of fossulae and septa more apparent; *23*, another specimen with an extravagant development of the septa; *24*, *25*, basal and lateral views of a smaller, thicker specimen showing the small area to which the epithecated portion of the base has been reduced; all ×1½. Mississippian (New Providence shale): Popes Chapel, Franklin quadrangle, Tennessee. (p. 201)

*26–28—Combophyllum osismorum* Edwards and Haime, 1851. Top, basal, and lateral views, ×3, of type, showing the calyx with the structure of *Hadrophyllum* and the basal part much as in *Baryphyllum* (after Edwards and Haime). Lower Devonian: Brest, France. (p. 196)




Bassler, Paleozoic Corals

UNIV. OF MICH.

Genotype: *Zaphrentis glans* White, 1862. Mississippian of Iowa and Missouri.

DIPTEROPHYLLUM GLANS
(White), 1862
Plate 32, figures 1–4

*Zaphrentis glans* WHITE, *1862*, Boston Soc. Nat. History, Proc., vol. 9, p. 32.
*Hadrophyllum glans* WHITE, *1883*, U. S. Geol. and Geog. Survey Terr., 12th Ann. Rept., pt. 1, p. 156. pl. 39, figs. 5*a*, *b*.—MILLER, *1889*, North Am. Geology and Paleontology, p. 191, fig. 179.—KEYES, *1894*, Missouri Geol. Survey, vol. 4, p. 116, pl. 13, figs. 11*a*, *b*.
*Dipterophyllum glans* ROEMER, *1883*, Lethaea geognostica, pt. 1, Leth. Pal., p. 372.

This species is readily recognized by its enlarged elongate basal portion ending in a sharp peduncular point of attachment and by the deep excavation made by the cardinal fossula; the calyx averages 14 by 12 mm. and the height or length of the corallum 14 mm.

Occurrence: Mississippian (upper Burlington limestone); Burlington, Iowa, and Louisiana, Missouri.

Holotype and hypotypes: U. S. Nat. Mus. 9316.

Genus BARYPHYLLUM Milne-Edwards and Haime, 1850

*Baryphyllum* EDWARDS and HAIME, *1850*, British Foss. Corals, p. lxvi; *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, pp. 165, 352.—SHERZER, *1891*, Am. Geologist, vol. 7, p. 278.—BASSLER, *1915*, U. S. Nat. Mus., Bull. 92, p. 102 (references).

In this genus the development of septa and fossulae on the upper side of the corallum is essentially the same as in *Hadrophyllum*, but the flattened under side exposes the septa over all its surface except on a small slightly depressed epithecated central area in which a minute sharply elevated peduncle occurs. This central area of attachment is so inconspicuous that the septa appear to occupy both sides of the corallum.

Genotype: *B. verneuillianum* Edwards and Haime, 1851. Mississippian of central Tennessee.

*Baryphyllum arenarium* Meek and Worthen is here referred to *Microcyclus* (p. 195).

BARYPHYLLUM VERNEUILLIANUM
Edwards and Haime, 1851
Plate 32, figures 21–25

*Baryphyllum verneuillianum* EDWARDS and HAIME, *1851*, Mon. Polyp. Foss. Terr. Pal., Arch. Mus. Hist. Nat., vol. 5, p. 352. pl. 6, figs. 7, 7*a*.—ROEMER, *1883*, Lethaea geognostica, pt. 1, Leth. Pal., p. 373, fig. 81.

The corallum in this interesting species is depressed circular averaging 18 mm. in diameter and 7 mm. high, although growth varies from thin flattened expansions to obese specimens 10 mm. high and 15 mm. wide. Base flat, exposing the edges of 24 major septa ending in a small depressed central area covered with epitheca from the center of which arises a minute pointed peduncle of attachment. Surface of corallum showing the four fossulae quite distinctly, the major septa attached to those outlining the fossulae and the few short minor ones united with the major. With age the septa become fused and often so twisted as to give a bizarre appearance.

This type of structure, although quite distinct from all other paleocycloid corals save that figured for *Combophyllum* is occasioned by the reduction of the epithecated base to a minimum.

Occurrence: Mississippian (New Providence shale); Popes Chapel, Franklin quadrangle, Tennessee (Devonian; Perry County, Tennessee, in error).

Hypotypes: U. S. Nat. Mus. 8050.

BARYPHYLLUM FUNGULUS White, 1878

*Baryphyllum fungulus* WHITE, *1878*, Acad. Nat. Sci. Philadelphia, Proc., p. 29.

This species, which still remains unfigured, has not been rediscovered.

Occurrence: Niagaran (Waldron shale); Waldron, Indiana.

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# THREE UPPER CARBONIFEROUS GASTROPODS FROM NEW MEXICO AND TEXAS

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ABSTRACT

*Pleurotomaria obtusispira* Shumard is redescribed and referred to *Omphalotrochus*. Two new pleurotomariids are described.

## 1. *Pleurotomaria obtusispira* SHUMARD AS A SPECIES OF *Omphalotrochus*

That the shell here under consideration belongs in the genus *Omphalotrochus* is by no means new. An undesignated species of *Omphalotrochus* has been mentioned in a number of papers in which the Hueco formation came under discussion, though some of these notices, I suspect, were concerned with a large *Euomphalus* that is also common. More specifically, an *Omphalotrochus obtusispira* is named in some lists of Hueco fossils and it is manifest that Shumard's species is referred to and that it is transferred from the genus *Pleurotomaria* under which it was described. Indeed, some of my own lists may cite it in this way, for its true relations have been known to me for many years.

Although the fact may thus be known to many that *Pleurotomaria obtusispira* is a species of *Omphalotrochus*, it has never received formal recognition. The original description, which appeared in 1858, is somewhat incomplete as well as somewhat in need of repair, as may be inferred from the transfer to a wholly unrelated genus, and the species has never been described again and never been figured at all.

In its first intent, the present paper purported to found a new genus of gastropods with Shumard's species as the genotype. A certain resemblance to *Omphalotrochus*, as based upon *O. whitneyi*, was recognized, but *P. obtusispira* was thought to offer a pronounced difference in a deflection of the growth lines which indicated that the peritreme had a deep sinus in the upper part below which it ran out into a beak-like projection. Other differences were noted but this seemed to be the most significant. In *O. whitneyi*, on the other hand, the growth lines were represented as essentially straight and as passing from the suture obliquely backward to the umbilicus. To this, the highly sinuous peritreme of *P. obtusispira* offered a striking contrast and pointed to important structural differences in the animals that secreted these respective shells.

Now in my conception of *Omphalotrochus*, I was relying with confidence on Meek's description, for I regard Meek as one of the soundest paleontologists that we have had. Furthermore, I had at hand only two poor specimens of *O. whitneyi*, and these yielded no information on the really

critical points. Partly on this account, my good friend J. Brookes Knight was called into my councils, and I was fortunate in so doing, for he happened at the time to have as a loan several fairly good specimens of *O. whitneyi* which showed that Meek's description was inaccurate in the very character by which I had thought *P. obtusispira* most deserved distinction as a separate genus—it has, namely, a sinuous peritreme, not so pronounced apparently as that of Shumard's species, but not essentially different. The other differences are by no means adequate for a generic distinction so that *Pleurotomaria obtusispira* seems to be a species of *Omphalotrochus* in perfectly good standing; it has nothing whatever to do with *Pleurotomaria*.

In spite of this somewhat disappointing outcome, it has seemed worth while in this article to rectify a highly important character of *Omphalotrochus*, to give *Pleurotomaria obtusispira* its proper status, to record my observations on the species, and to supply figures which have up to now been lacking. I have examined a great many specimens of *O. obtusispira* and am able to add many details to Shumard's description besides augmenting our knowledge of a genus which, so far as known, contains few American species.

OMPHALOTROCHUS OBTUSISPIRA
(Shumard)
Plate 33, figures 1–17

*Pleurotomaria obtusispira* SHUMARD, *1859*, St. Louis Acad. Sci., Trans., vol. 1, p. 401.

The original description of *Pleurotomaria obtusispira* appeared in a publication now rather rare (*Notice of fossils from the Permian strata of Texas and New Mexico*), and it will, I believe, serve a useful purpose to quote it in full. It runs as follows:

> Shell large, trochiform, depressed, conical, truncated at apex, strongly carinated at base and gently convex beneath; volutions six or seven, the two apical turns gently convex and scarcely visible when the shell is viewed in profile; last volutions flat or slightly convex, strongly carinated at base; carina rounded, bearing the band of the sinus and limited above and below by a distinct revolving depression; suture distinctly marked; umbilicus large, round; surface marked with extremely fine striae of growth; aperture varying from ovate to subquadrate.
>
> The spiral angle of this species varies considerably with the age of the shell. The angle of a full grown specimen is 84°, of a young specimen, 56°.
>
> Locality.—Coal Measures, 4 miles west of the Sierra Hueco, El Paso County, Texas.

The fact that Shumard did not figure *Pleurotomaria obtusispira* places difficulties in the way of recognizing it again, difficulties which in many species would be insurmountable. In this instance, however, there can be no reasonable doubt that the species here called *Omphalotrochus obtusispira* is the one that Shumard described. Not only does the form with which I am dealing occur in most collections from the Hueco limestone of the Hueco Mountains, so that Shumard would likely have obtained specimens of it, but some of my specimens in a general way came from the same locality as his. Furthermore, the species is of itself rather outstanding if for no other reason than its size, and my specimens are in close agreement with Shumard's description.

*O. obtusispira* proves to be a very variable species and one line of variation is the spiral angle. Shumard also animadverts upon this but he attributes the variation to age, claiming that young

shells have a narrower spiral angle than old ones. Now large or mature specimens that retain all the earlier volutions are almost unknown, and the facts might be expressed in a general way by saying that all the mature specimens have a broken spire and that all the specimens whose spire is whole are immature.

It is clear that the two measurements given by Shumard were taken from different individuals and the inference seems reasonably safe that the spiral angle ascribed to a full-grown specimen was measured on one which lacked the earlier volutions and that the spiral angle ascribed to a young specimen was measured on one to which the mature whorls had not yet been added. Instead, therefore, of the spiral angle being 56° in the immature stage of a single normal individual and widening to 84° at maturity, the spiral angle in each of his specimens may have been constant, the difference being due to individuality rather than to age. Among my specimens some young ones have a wide spiral angle and some mature ones a narrow spiral angle and vice versa. It probably is true, however, that the spiral angle widened more or less as the shell gained size and in some very old specimens the last volution does not follow the slope of the spire but marks an almost abrupt projection laterally. On the other hand, it is also true that owing to compression, or to the absence of most of the spire, some specimens appear almost lenticular and offer a deceptive resemblance to the genus *Euomphalus*. It is hard to conceive of them as having been high-spired like the rest. It has already been remarked that complete shells are extremely rare and it is interesting to find that many of them appear to have been broken before fossilization, so that in that item at least their condition is now essentially the same as when they were buried in the sediments that constituted the Hueco formation.

As just remarked, *Omphalotrochus obtusispira* is rather common in the Hueco formation and is one of its most characteristic fossils. I have examined specimens from over 50 localities in the Hueco Mountains, the Diablo plateau, the Cornudas Mountains and the Carrizo Mountains. My material shows that the species is subject to great variation without affording any basis that I can discover for specific subdivision. It would be hard to name a character in which variation has not been observed and as the characters do not vary concomitantly, there results a diversity of combinations which it would be hopeless to try to describe. Furthermore, since the volutions become greatly transformed as the shell passes from youth to maturity and then to senescence, some of the variation, inasmuch as no obtainable specimens are complete for all stages, is due to comparison of specimens at different periods of growth.

Variation in the spiral angle has already been mentioned, and between selected specimens the difference may be very conspicuous. Though the spiral angle, as Shumard seems to claim, may widen somewhat with growth, the ontogenetic change was much less than he supposed and the difference between specimens in this character was almost wholly an individual difference. It could, and probably did, proceed from variation in the shape of the constituent whorls (as exceptionally high or exceptionally wide) or from variation in the way one whorl was applied to that which went before (as mostly to one side or mostly beneath it) or from both in combination.

The carina in general terms is a stout, blunt ridge which is commonly emphasized by grooves above and below it. The groove above the carina is apt to be narrow and rather deep; that below it is commonly shallower and less well defined. Either of the grooves, or both of them, may be undeveloped. If both are obsolete the carina is scarcely more than a rounded angle where the basal and lateral surfaces come together, but if they are well developed, the carina projects strongly. The upper groove, where

most highly developed, may be deep and abrupt; the lower groove, though commonly hardly more than a shallow deflection, may be more pronounced than the upper and on one specimen it occupies the peripheral half of the basal surface with an abrupt rise to the axial half. The carina is at least subangular on the earlier volutions, but as growth proceeded it became broader and not uncommonly more or less flattened peripherally. In some specimens it even became indented by a median groove so as to appear double. It may have been this configuration which led Shumard to think that a slit-band was present on the carina and to describe the species as a Pleurotomaria. It will be shown later on that there is far from being a slit-band on the carina or a slit in the peristome; and if the bicarinate shape of the periphery was what misled Shumard, the carina should, to convey the slit-band, have that shape on all specimens and in any one specimen not only in the last volution or two but in all of them. This is far from being the fact.

The upper surface of the normal volution at the mature stage is essentially flat, the only conspicuous deflection being the groove (not always conspicuous either) that lends emphasis to the carina by occurring just above it. Not uncommonly the surface below the suture is slightly convex, creating a sort of groove as it merges with the part below, or slightly concave, creating a sort of ridge which may be faintly defined on its lower side also. In some specimens a narrow shallow groove is developed on the lower part of the lateral surface a short distance above the one that bounds the carina and in the exceptional specimen the intervening areas are quite tumid so that the contour of the lateral surface appears to be made up of three arches separated by grooves, the upper and lower arches being narrow and the lowest groove being the one that occurs on the upper side of the carina. On the same specimen the whorl preceding such a one may be flat and featureless.

In a general way, at least, the section at the mature stage is irregularly foursided, and if I may assume one specimen to be more or less characteristic, the impressed zone is the narrowest, the lateral and inferior zones are of about equal width and are the longest, and the umbilical zone is intermediate. The outline of the lateral zone, from the suture to the carina though slightly sinuous, is nearly straight and strongly oblique. The outline of the basal surface is nearly straight except near the periphery where it curves upward to the carina and in the main part it is almost horizontal, though having a gentle slope downward toward the axis. At the umbilicus the outline makes an abrupt right angle turn so that on the umbilical side it is almost straight and almost vertical. In the impressed zone the outline is strongly concave and strongly oblique from the suture inward. At the sutural end it projects in an acute angle; at the umbilical end it also makes an angle though one which is obtuse. Where these observations were made the whorl had a diameter of 15 mm. The shape and direction of the impressed zone and to some extent its length would vary with the shape of the preceding whorl and other circumstances. In some specimens this zone would be much more gently convex and more nearly horizontal than in the one described.

At the aperture the shell thins to a knife edge and the peristome has the quadrate shape above described. As in many gastropods, however, the volutions become very thick through additions to the inner surface and these are so applied as to neutralize the irregularities of the exterior; consequently at a certain distance back from the aperture the inner whorl section is essentially circular but the thickness of the shell varies from point to point. It is very thick along some zones and thinnest along the middle of the impressed zone. Many specimens af-

ford evidence suggesting that in this thickened shell the external and internal parts differed in chemical composition or in physical construction. In some instances this apparent differentiation is due to silicification which, as often happens, has affected the outer layers of the shell while the inner layers remain calcareous. This selective action itself suggests a dual composition and I believe that such was indeed the fact, but the evidence is not unquestionable.

The growth lines just below the suture are for a short distance straight or gently convex, and in direction, almost transverse. They then make a broad concave arc which, though turned slightly backward in the upper part has in general a strong slant forward, and is so prolonged in the lower part that the point where it ends, at the carina, is far in advance of the point where it begins, at the suture. The short section below the suture that is straight or convex corresponds in position to the narrow zone which, as already described, is commonly recognizable in the configuration. The growth lines pass over all the other features of configuration where any are present, without being deflected by them. At the carina, however, the growth lines, which have there a conspicuous forward direction, turn abruptly backward and make a broad concave arc across the lower surface with a generally oblique direction. In this way the growth lines, above and below meet at an acute angle at the carina and where the carina has a two-edged configuration, the angle coincides with the upper edge. The peritreme, consequently, projects strongly at the carina and recedes above and below it. As they near the umbilical shoulder the growth lines on the lower surface are in direction, essentially perpendicular to the axis. They form an almost straight line in passing up the umbilical surface, where they are vertical, and across the surface of contact, where they are more or less horizontal (or on a rising plane). Thus, instead of retreating into a slit at the end of the carina, which it would necessarily do if the species were one of the Pleurotomarias, as described by Shumard, the peristome runs out into a point at that place.

In general terms, the volutions overlap to the outer margin of the carina. Where this happens the result is a conical shell with flat sides in which the carina is not conspicuous nor the suture depressed, though it is invariably distinct. In some specimens, however, the overlap does not extend to the extremity of the carina which thus forms a sort of flange winding up the spire. Indeed, this configuration seems regularly to characterize the stage where the carina occupies a median position on the whorls before it has migrated to the basal line.

Aside from features described above, which may be classed as configuration rather than sculpture, the shell is without ornament and marked only by growth lines, which are commonly distinct. A few specimens show rather regular fine spiral lines on the lower surface but this is apparently a structural feature. These specimens are coarsely silicified and probably have lost some of the outer layers of shell. Specimens in which the surface is well preserved show nothing of the sort. One specimen, in spite of the fact that it is silicified, retains what one would otherwise not hesitate to call original coloration. A certain area on the last volution is marked by elongated patches which are darker than the prevailing tint and which pass partway across the volutions with a strong backward obliquity—some in the lower part, some in the upper, and some more or less continuous. A few other specimens have a blotched appearance which may be the remains of coloration in the shell itself, but which may also be due to coloration of the siliceous material by which the shell has been replaced.

Whatever is said about the development of the shell in this species must be based on observations of only a few specimens, or pieced together from ob-

servations more or less scattered. In the earlier stages the volutions were rounded and complanate. In most specimens where the earlier volutions are retained the very earliest ones are missing, and the observer might suspect that the initial whorl made an open turn so that the umbilicus, though smaller, was as unobstructed at the top as at the bottom. Several specimens show that this was not so. The initial shell appears to have been a minute sphere and the first three or four volutions appear to have been circular in section, complanate and merely tangent to one another without overlap. At this stage the diameter in one specimen is about 4 mm. and the shape is discoidal with the upper surface slightly concave. The volutions now begin to develop a carina and to assume a spiral growth. The carina soon passes below the median line, but the surface above it is narrow and well-arched and the line of contact with the volution next following—that is, the suture—well below it. The spire at this stage is very uneven by reason of the projecting side of the volution enhanced by the carina. The general tendency thereafter is for the lateral surface to become broad, flat, and oblique and the lower surface to become flat and horizontal with the carina shifted from a lateral to a basal position. At the same time the overlap of one volution on its predecessor is extended to the outer margin of the carina which consequently projects but slightly in the general contour. The shell at this stage would be regularly conical with flat even sides.

In what appears to be the post-mature or gerontic stage the volutions seem to revert to the shape that they had in the immature condition. The lateral surface and the lower surface become rather highly and regularly arched so that the volution is almost circular in cross section. The impressed zone becomes so narrow and so shallow as to be almost indistinguishable. The irregularities of contour that characterize the mature stage are diminished or lost, among them the abrupt turn between the flattened basal and flattened umbilical surfaces. The carina and its beak-like extension on the peristome, however, remain unchanged. Furthermore, this last volution does not conform to the descent of the spire but juts outward as if to begin a more complanate style of growth. Most of the differences between specimens are probably due to some of these ontogenetic changes beginning earlier in the course of growth than is normal or persisting later.

Almost every specimen has some modification of this process of development. Some are conspicuous for the uneven shape of the spire in the early stages and it is only in the very late ones, if at all, that the volutions so overlap that the carina does not make a distinct break in the outline. On the other hand, some specimens attain what may be called mature characters at an early stage. The volutions very early overlap to the extremity of the carina and the spire for nearly its entire length has almost even sides. Between these two extremes almost every variation can be found. I hesitate to generalize in the matter of development, but the controlling factor in determining whether the spiral angle shall be broad or narrow is the degree of curvature made by the volutions in winding about the axis, though their rate of enlargement would also modify the spiral angle. In a general way it would seem that in shells with a narrow spiral angle the volutions were less apt to overlap to the extremity of the carina which then projected more or less at all stages, giving the spire a correspondingly irregular outline, but in shells with a wide spiral angle the volutions overlapped completely and constructed a conical shell with relatively even sides.

It is uncertain how many volutions should be classed as mature and more or less senescent, perhaps four. Nor can the total number be given with assurance, for specimens that show the earlier

ones do not retain the later and vice versa, but if the initial stage with rounded volutions comprises 3, the mature stage 4, and if an allowance of 2 is made for an intermediate stage, the total number may tentatively be given as 9. Few specimens retain more than 3 or 4, however. In this connection it is necessary to state that these shells appear to be as variable in their immature condition as they are at maturity. Although very young specimens in good condition are scarce, the evidence seen indicates that the change from a complanate to a spiral growth takes place earlier in some specimens than in others and that the discoidal shell may comprise fewer volutions than four and be appreciably less than 4 millimeters in diameter before a spiral growth sets in.

As already mentioned, the sinuous shape of the aperture in which *O. obtusispira* differs so strikingly from *O. whitneyi* as described by Meek, constitutes a difference that does not really exist, for *O. whitneyi* is now known to possess essentially the same character. It can hardly be doubted that both species belong to the same genus, and a few other differences, even if they cannot be explained away, lose much of their force in view of the disappearance of this more radical one. As an instance, Meek suggests that the peritreme in *Omphalotrochus* is not entire, as it certainly is in *O. obtusispira*. "The aperture," he says, "is not modified by the preceding turn" or again "the shell seems to have its peritreme scarcely continuous, or, at any rate, very thin on the side connecting with the preceding whorl." In *O. obtusispira*, on the other hand, there is a very pronounced zone of contact, and although the shell is quite thin at the median line of this zone, it thickens strongly in both directions so that the aperture is profoundly modified by the preceding volution.

It should be recalled, however, that in *O. obtusispira* also the shell at the aperture, if not broken, is extremely thin, though it is thin not only at the zone of contact but over its entire circumference, and also that the zone of contact, which is broad and deep at the mature stage, may thereafter almost disappear. At this post-mature stage, consequently, the shape of the aperture is not materially modified by the preceding turn, and the peritreme here also, though certainly continuous, is very thin at the zone of tangency. Consequently a certain agreement can be traced between *O. obtusispira* and *O. whitneyi* in these particulars.

From the evidence at hand it seems almost certain that *O. obtusispira* and *O. whitneyi*, though now recognized as congeneric, are distinct species. In the specimen represented by figures 12 and 13, the shape of the last volution is more or less comparable to that of *O. whitneyi* though the volution is not nearly so high, and the part which may be called a lateral zone in *O. whitneyi* is, if homologous at all, much narrower and less differentiated. The last whorl in this specimen of *O. obtusispira*, however, appears to represent a gerontic condition; the preceding whorls have flat oblique sides and construct a spire whose shape is regularly conical, or in other specimens interrupted by the projection of one volution beyond the one next following. In *O. whitneyi*, on the contrary, all the volutions, except possibly some of the early ones, seem to be modeled on the same plan and have a relatively broad lateral zone differentiated from zones above and below.

It seems highly unlikely that the acquisition of more material (for of *O. whitneyi* at least, few good specimens are known) will obliterate the differences pointed out above, or others yet to be recognized, but it may be well to note that *O. obtusispira* antedates *O. whitneyi* by five years, being described in 1859, while Meek's species was not described until 1864.

## 2. TWO PLEUROTOMARIID GASTROPODS FROM THE ABO(?) SANDSTONE OF NEW MEXICO

PHANEROTREMA PRETIOSUM Girty, n. sp.
Plate 33, figures 22–24

Shell, small, turbinate, much wider than high, composed of about five gradually enlarging volutions. Suture distinct but not deeply depressed. Final volution strongly and somewhat irregularly rounded. The upper surface from the suture outward for a considerable distance, or more specifically to the slit band, conspicuously flattened and oblique. Below the slit-band, which also interrupts the curvature though only slightly, the direction is somewhat oblique from above outward. The curvature then strengthens until the direction is reversed and the shell turns backward to the axis. The peripheral line, therefore, lies below the middle of the volution and the slit-band above. The volutions embrace to the lower boundary of the slit-band.

The sculpture consists of fine spiral lirae without any transverse liration except fine growth lines and except for short-lived plications near the suture. On the type specimen there is a narrow spiral ridge adjacent to the suture and below the ridge four or five rather slender spiral lirae. These lirae are somewhat narrower than the intervals between them, and a still wider interval separates the lowest one from the slit-band. The slit-band is defined by sharp lirae about like those just mentioned and in width it is about equal to the unstriated zone immediately above it. A similar, though somewhat wider, unstriated zone occurs below the slit-band, but below this the surface is marked by slender, sharp revolving lirae to the number of nine or ten. This striated area is followed on the lower part of the volution by a broad space without spiral lines beyond which, in the region of the axis, spiral lines are again developed to the number of four or five. All the lirae are very slender and rather far apart.

Beginning at the suture the surface is crossed by slender transverse costae which are developed on about the same scale as the spiral lirae, though here the costae are broad and the grooves narrow. The costae give rise to small but conspicuous nodes on the spiral features, relatively large nodes on the ridge below the suture and correspondingly minute nodes on the lirae below it. The transverse costae, which may be considered as fascicles of growth lines, die out completely in passing downward so that the two lowest spiral lirae are not affected by them, and are practically smooth instead of nodose. The rest of the surface shows only fine regular incremental lines, though the basal part is given a faintly undulating appearance by somewhat stronger striae spaced at more or less regular intervals, marking stages of growth. On the slit-band the transverse markings make the usual concave arc, but here also they are no more than fine incremental lines. In direction the transverse lines are gently curved and gently oblique from the suture to the slit-band, near which they have a pronounced backward direction. Over the smooth zone below the slit-band they are convexly arched, in fact, this zone looks like a second slit-band though with the deflection of the growth lines reversed. Below this zone the growth lines have a backward slope and a somewhat sinuous course, tracing a long shallow concave curve over the basal region followed by a short but gentle convex curve to the axis. The shell is much thickened and apparently reflexed in the axial region, effectively closing the umbilicus.

This species is distinguished by its small size, by the low spire scarcely interrupted by the suture, and by the fine scale of its surface markings, especially those having a transverse direction which are no more than delicate growth lines except as they group themselves into

costae for a short distance below the suture.

Horizon and locality: Abo sandstone (?); reddish to buff calcareous sandstone beside the road in the lower part of Grapevine Canyon. Otero County, New Mexico (station 6082).

PLEUROTOMARIA PLANICOSTATA
Girty, n. sp.
Plate 33, figures 18–21

Shell broadly turbinate, considerably wider than high, composed of about six gradually enlarging volutions. Spire low; suture deeply depressed; volutions strongly and regularly rounded, curving somewhat downward to the suture so that the upper part of the volutions is faintly tabulate. The slit-band is a narrow depressed belt, situated on or just below the periphery. The volutions embrace to the lower margin of the slit-band. The umbilicus is closed.

The sculpture consists of coarse spiral lirae without any transverse lines of corresponding size. The spiral ornamentation might better perhaps be described as consisting of incised lines, for the lirae are broad and but faintly arched on top, while the striae between are only sufficiently wide to define them sharply. On the type specimen there are eight lirae between the suture and the slit-band. In this number is included the obscure shoulder at the top of the volution which, as a lira, is defined only on its lower side

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EXPLANATION OF PLATE 33

Figures natural size except *3*, *6*, ×2; and *18–24*, ×5.

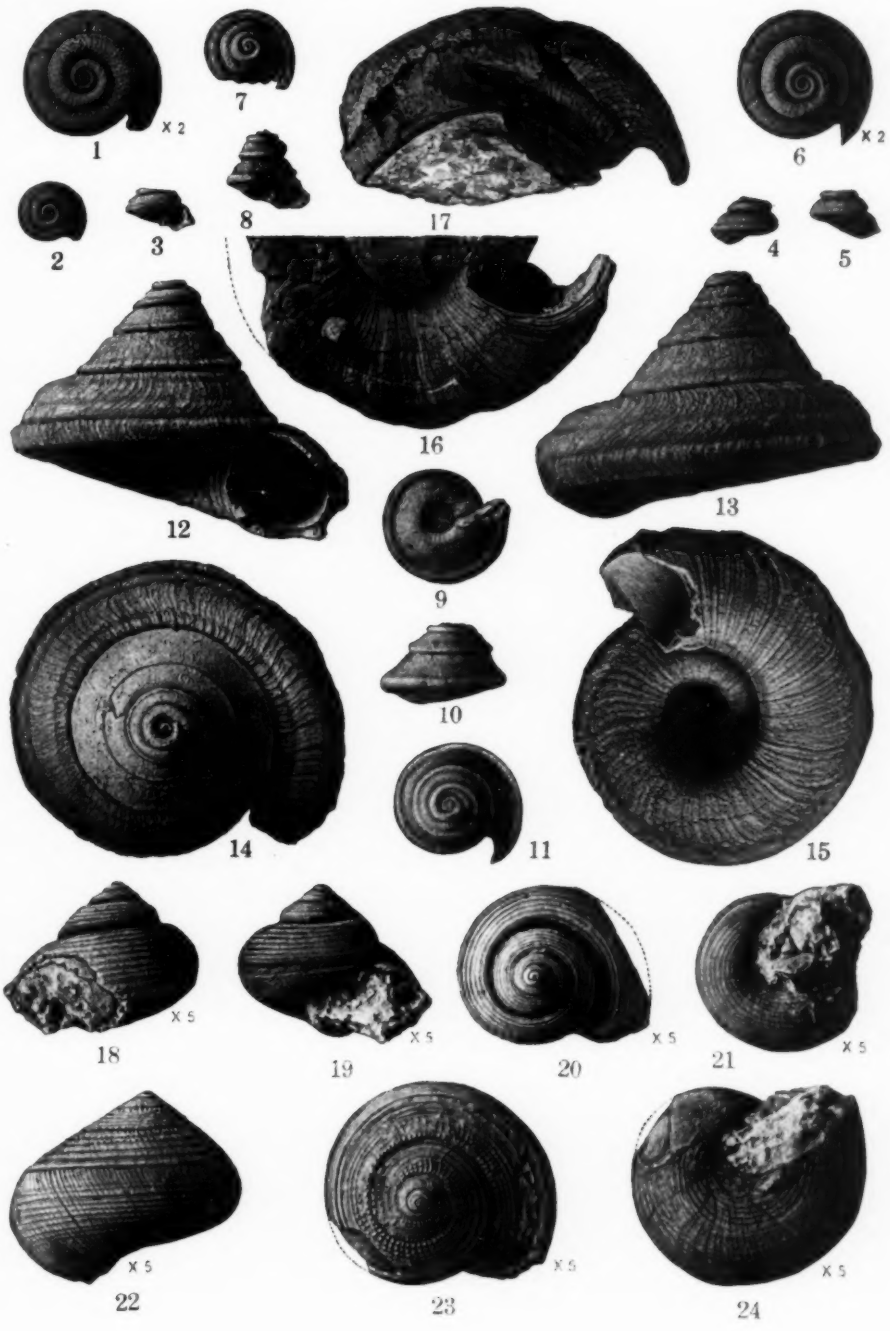
The originals of *1–6*, and *9–11* came from the Hueco formation in the Hueco Mountains; the original of *7*, *8* came from the Hueco formation in the Franklin Mountains, opposite Vinton; the original of *12–15* came from equivalent beds on Gym Peak in the Deming quadrangle; and the original of *16–17* came from equivalent beds in the Sierra Tinajas Pintas. The numerous specimens examined indicate that such differences as can be seen in these specimens are due to individual peculiarities and are not in the nature of regional or local developments.

The originals of *18–24* came from the Abo(?) sandstone in the lower part of Grapevine Canyon, Otero County, New Mexico.

FIGS. *1–17*—*Omphaloirochus obtusispira* (Shumard). *1–3*, Three views of a young specimen; the side view, *3*, has a flat top because a number of the early whorls are complanate; they are also almost circular in section as seen in *1* and *2;* the side view shows how the last volution present has started off at a decided angle and has developed a carina. *4–6*, Three views of a young specimen representing a somewhat more advanced stage than the preceding. *7*, *8*, Two views of a specimen which has an exceptionally narrow spiral angle; initial whorls missing; the assumption of mature characters appears to have been accelerated. *9–11*, Three views of a partly-grown specimen; the top of the spire is damaged as usual, but the peritreme is entire; a comparison of *9* and *11* illustrates how the upper part of the peritreme projects beyond the lower; some of the matrix is visible in the lower view, *9*, but none of it can be seen in the upper view, *11*, as it is concealed by the shell. *12–15*, Four views of a large and unusually perfect specimen; even this specimen has lost some of the initial whorls and is imperfect at the aperture; the last volution seems to show post-mature characters, as it juts out rather abruptly from the regularly formed conical spire, and has acquired spiral grooves and ridges, absent from, or only suggested in the earlier whorls; in some specimens, at a still more (?) gerontic stage the final volution is almost circular in section, has lost its spiral grooves and ridges, and has only a linear contact with the preceding volution. *16*, *17*, Two views of part of a crushed and generally imperfect specimen which, however, retains the peritreme unbroken; *17* shows the last volution viewed from above—note the deep sinus in the outline and the beak-like projection of the peripheral surface; *16* shows the last volution seen from below; the outline here is not sinuous but forms a gentle concave curve; note that this figure, like *9*, illustrates the projection of the upper part of the peritreme beyond the lower, the upper part of the last volution being visible at the aperture when the shell is viewed from the underside. (p. 203)

*18–21*—*Pleurotomariata planicostata* Girty, n. sp., four views of the holotype. (p. 210)

*22–24*—*Phanerotrema pretiosum* Girty, n. sp., three views of the holotype. (p. 209)




Girty, Permian Gastropods

UNIV. OF MICH.

Furthermore, the two lirae above the band are separated by an incised line that is weaker than the incised lines above so that they appear distinctly paired. The surface adjacent to the suture, including the obscure shoulder some distance away from it, shows only doubtful traces of spiral lines. The lower surface, that which extends from the slit-band to the axis, is marked in the same manner as the upper surface, though somewhat less distinctly. The slit-band is sharply defined by incised lines, and as already described, it is depressed below the surrounding surface. It is slightly wider than the widest of the spiral lirae. The transverse markings consist of fine inconspicuous growth lines among which striae, somewhat stronger than the rest but still very faint, mark stages of growth. Except for such stronger striae the transverse markings of the lower surface are almost obsolete. On the slit-band transverse lines are distinguishable here and there, and they have the usual concave shape, but they are in no wise comparable to the sharp lunettes of other Pleurotomarias. In direction the transverse lines are gently concave and strongly oblique from the suture to the slit-band; from the slit-band to the axis they are almost straight and almost direct.

This species is distinguished by its small size and depressed shape, by its regularly rounded volutions, by its narrow, depressed, sharply defined slit-band, and by its spirally striated surface on which transverse lines, except obscure growth lines, are wanting while the spiral lineation suggests slender lines engraved on a rounded surface rather than slender lines embossed on such a surface. It resembles several Carboniferous species in one respect or another, but differs from them markedly in the remaining characters. Thus it lacks the folds or wrinkles that on *P. beckwithana* extend outward from the suture; it has broad instead of narrow revolving lirae and a narrow depressed slit-band instead of a broad elevated one. With *P. carbonaria* and *P. newportensis* it hardly need be compared, though a certain general resemblance is obvious. The same is equally, or even more true of *P. insecta*, which Conrad described under the genus *Turbo*, but which I can scarcely doubt is a species at least congeneric with *P. carbonaria*. *P. planicostata* is comparable to *P. broadheadi* in that the revolving lines are aptly described as impressed instead of raised, but there any close resemblance ends. To none of the described species probably does it stand as close as it does to *P. valvatiformis*, as seen in Meek and Worthen's figures, which however are enlarged to $5\frac{1}{2}$ diameters, so that *P. planicostata* is well nigh as much larger than that species as it is smaller than the others mentioned. I note also that the slit-band in *P. valvatiformis* is not depressed and that the spiral striation is apparently finer and more indistinct though perhaps not more so if the difference if size is taken into consideration. On this point nothing definite can be said, as I have not seen specimens of *P. valvatiformis* and as Meek and Worthen are not specific.

Horizon and locality: Abo sandstone (?); reddish to buff calcareous sandstone beside the road in the lower part of Grapevine Canyon, Otero County, New Mexico (station 6082).

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# KERIOTHECAL WALL-STRUCTURE IN *FUSULINA* AND ITS INFLUENCE ON FUSULINE CLASSIFICATION

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ABSTRACT

Lately the most generally accepted basis for distinguishing the Schwagerininae from the Fusulininae has been the keriothecal wall-structure of *Schwagerina*, *Triticites*, and related genera, and the supposed absence of such structure in the Fusulininae. It was known by those who accepted this criterion of distinction that the occurrence of very fine, nearly obscure keriotheca in *Fusulina* from Asia has been mentioned in the literature, but inasmuch as most students of the group have not succeeded, even after diligent effort, in verifying those observations, the opinion has prevailed that very fine columnar jointing of a sort was mistaken for keriotheca. Recently, however the issue has again been raised by Galloway, who has presented definite measurements of keriothecal pores in *Fusulina*. By staining out, typical keriotheca is clearly resolved in well-known species of *Fusulina* from the Mid-Continent region. These circumstances force a reexamination, which is set forth in this paper, of the present scheme of classification and the current notions of fusulinid phylogeny. It is proposed that we continue to recognize the genera and two subfamilies affected but revise their definitions.

The wall-structure of Pennsylvanian Fusulinidae has been regarded until recently as of two kinds, the *fusulinellid* and the *schwagerinid* or *keriothecal*. The fusulinellid wall was supposed to be characterized by three layers of shell substance: the outer, thin, dark layer called the *tectum;* a median, thicker and more translucent layer, the *diaphanotheca;* and the inner, irregular, secondary covering, the *tectorium*. Adjacent to the tunnel, a pair of levee-like ridges, known as the *chomata*, composed of the same substance as the tectorium are broadly developed in the fusulinellid shell. I am applying the term *epitheca* to all secondary shell material such as tectorium and chomata, and the term *protheca* to the primary wall-layers. The schwagerinid wall-structure was supposed to be composed of *tectum*, as above, and an inner, thick, honeycomb-like wall called *keriotheca*, epitheca, if present, being limited mainly to the chomata.

One group, to which the writer belonged, thought with some uncertainty that diaphanotheca is as structureless as it appears, but another maintained that diaphanotheca is porous, like keriotheca, and that the alveoli can be seen only under very favorable conditions of preservation. According to the second group, diaphanotheca is merely keriotheca or a variety thereof. Upon supposed distinctions between these two types of wall-structure, the Pennsylvanian fusulinids have been divided into two subfamilies, known since 1930 as the Fusulininae and the Schwagerininae.

## SIGNIFICANCE OF THE PROBLEM

The importance of the problem can best be explained by reviewing briefly the history and present under-

standing of wall-structure as a means of classifying genera and working out the racial relationships of the family.

The fusulinellid wall-structure was first described by Möller (15) in 1877 for a new form that he later named *Fusulinella bocki* and that appeared to differ from the other fusulinids then known by having conspicuously thick tectorium and a clear, inner layer corresponding in position with but lacking the honeycomb structure of keriotheca. It is worthy of note here that Möller supposed the diaphanotheca to be the filling by clear, secondary calcite of a canal system; an obvious fallacy that Schellwien later pointed out.

Not until the last 25 years were attempts made to organize the fusulinid genera into a taxonomy that would represent their racial relationships. The most notable of these attempts were made by Staff and Wedekind (1910), Ozawa (1925 and 1928), and Dunbar and Condra (1927). Since 1927, the system of classification erected from the results of studies by Dunbar has been considerably altered in its formal, nomenclatorial aspects by Dunbar and Henbest (1930). Following 1930, the chief changes are addition of several new genera by Galloway (1933) and Lee (1933), and the purposedly practical and simplified classification proposed by White (1932). A history of fusuline taxonomy would be incomplete without mentioning the important work on the fusulinids of China by Lee (12, 13) and Lee, Chen, and Chu (14), in which significant comments on questions of classification were presented.

Staff and Wedekind used the symmetry of the junvenarium (20) as the determining feature in their organization of the family into three sub-families, not including the Neoschwagerininae. Ozawa did not follow the Staff and Wedekind scheme but divided the genera and subgenera into two subfamily units. The classification proposed by Dunbar and Condra placed special importance on the structure of the shell wall; accordingly, the Lower and Middle Pennsylvanian genera were grouped together by them as the subfamily "Fusulinellinae" (now Fusulininae (4)), because they all have in common, in addition to other more or less characteristic features, the wall-structure typified by that of *Fusulinella*. The Upper Pennsylvanian and Permian genera were set apart from the "Fusulinellinae," because of their keriothecal wall-structure but were divided into three subfamilies. Of these, genera having keriotheca and, in general, the morphology of *Triticites* were called the subfamily "Fusulininae" (now Schwagerininae). Those having more or less highly specialized keriotheca and secondary septa were called the Neoschwagerininae, and those having parachomata, among other peculiar structures, the Verbeekininae. Therefore, on the bases just stated, the system of Dunbar and Condra involved a complete reorganization of the classification proposed by Staff and Wedekind.

In 1930, a revision of the Dunbar

and Condra classification was published by Dunbar and Henbest (4). In this they attempted to remedy the confusion created by Möller's redescription of *Fusulina cylindrica* Fischer as having a wall-structure like that of *Triticites* and *Schwagerina*, and they revised the nomenclature to accord with the International Rules. The original classification, and later the revised classification, has rather generally been accepted.

In summary, the anatomical features of external form, degree of septal plication, number of tunnels, symmetry of the juvenarium, growth characteristics, and character of chomata are rated as having only generic and specific values. The larger aspects of fusuline classification and phylogeny are at present intimately related to and based upon our ideas of shell wall-structure and composition.

## PRESENT STATUS OF THE PROBLEM

The present situation revolving around the problem of diaphanothecal structure is not entirely a new development. The problem arose with special force when Dunbar and Condra (1927) and Lee (1927) published near the same time but independently their opposing views on the character of diaphanotheca and the usefulness of wall-structure in taxonomy. Lee, being aware of the growing emphasis on wall-structure, called attention to his observation of keriotheca in *Staffella*, *Fusulinella*, *Fusulina* (including "*Girtyina*" of Staff, Lee, and others), and *Wedekindellina rawi* (Lee), but he was uncertain about the presence of keriotheca in *Boultonia willsi* Lee. These observations, he thought, placed a special difficulty in the way of using diaphanotheca as a means of distinguishing and grouping genera. At the same time Dunbar and Condra were investigating the more or less uncertain reports of keriothecal structure in the fusulinellid wall, but as the published evidence then available was unconvincing and as the fusulinellid specimens at hand exhibited clear, structureless diaphanotheca, they took advantage of this character as one offering a simple and natural basis for taxonomy. They took this course with some misgivings, however, as one can see in their discussion of the ultimate nature of diaphanotheca (2, p. 21).

It is of interest to note here that not until recently have reliable illustrations of keriotheca in the fusulinellid shell wall appeared in the literature. Möller's illustrations of topotypes of *Fusulina cylindrica* Fischer as having coarse-textured keriotheca are unconvincing because the figures contain obvious interpretive additions. Whether Möller actually saw keriotheca in those specimens may be questioned. The topotypes of *Fusulina cylindrica* that I have seen bear adequate evidence of the threefold wall-structure typified by *Fusulinella*, but I strongly doubt that any of them exhibited the relatively coarse-textured keriotheca that Möller illustrated.

Unaware of the trend of Dunbar's studies and Lee's studies, I arrived independently at the same conclusion

as Professor Dunbar that diaphanotheca lacks porous structure. This conclusion was reached after an intensive study in 1926 of a few species of *Wedekindellina* and *Fusulina* from southern Illinois. After a diligent and careful search through my thin sections and through published photomicrographs, only a few very dubious examples of keriothecal structure were found, and even these examples appeared explainable at that time as an effect of columnar jointing on a microscopic scale.

Recently, however, Lee's observations of keriotheca in members of the subfamily Fusulininae of North China have been duplicated by Galloway and White in their work on the Oklahoma and Texas fusulinids. Still more recently, while engaged in some routine identifications of specimens of *Fusulina* from the Holdenville formation of Oklahoma, I succeeded in staining very clearly resolvable keriotheca in the last two volutions by immersing the specimens for about two weeks in xylene containing powdered malachite green. Following that, the method was tried on collections, some of which had previously yielded negative results, even when examined by polarized light and by dark-field illumination. A list of those that proved to have keriotheca includes *Fusulina* sp., from the Holdenville formation of Oklahoma; *Fusulina girtyi* (Dunbar and Condra); *Fusulina haworthi* Beede (topotypes and metatypes), from the lower Fort Scott limestone at Fort Scott, Kansas; *Fusulina* sp. aff. *F. euryteines* Thompson; and *Fusulina girtyi* (Dunbar and Condra), from central Missouri.

More recently many other examples have been found. I have tried again to differentiate by staining the details of shell wall-structure in topotypes of *Wedekindellina euthysepta* but have had only dubious success; however, a reëxamination of the original types by means of a carefully adjusted and well-corrected optical system disclosed the existence of structure in the holotype and second paratype that I confidently interpret as keriotheca. These examples and one from southwestern Illinois indicate that the keriotheca of *W. euthysepta* resembles that of *Fusulina*.

It is hardly possible to deny the keriothecal structure of diaphanotheca, because it has been observed by several students of fusulinids in specimens from different parts of the world and because it is possible to resolve the alveoli by staining well-preserved specimens, even though before staining the diaphanotheca appears to be clear and structureless.

The ultimate structure and composition of the fusulinid walls has been a matter of debate for a long time. The majority of students have refrained from expressing positive opinions about the agglutinate or the calcareous character as the case may be of the shell material. Since the present paper was first presented (10), Gübler (7) has suggested that the wall material, particularly keriotheca, was originally prismatic and that the alveoli were not originally minute pores but prisms of clear calcium carbonate. The sug-

gestion is being treated at length by Professor Dunbar, but I shall mention in passing some of my own observations on the question. Fractures of early origin accompanied by a vertical displacement through the walls generally show that as far as possible the alveolar walls remain intact and to the greatest possible extent the fractures pass through the alveoli—the weakest zone because of being hollow—in the same way that brittle honeycomb would fracture. Alveoli very commonly stain very deeply because of their containing clay and other foreign matter that entered during burial. In general, alveoli will stain if the matrix stains, but if the matrix is pure lime, both it and the alveoli will stain poorly if at all. Keriothecal pores may be regarded as analogous to the pores in the spiral wall of *Bradyina* and *Glyphostomella*. The wall material of keriotheca and epitheca generally appears granular. Galloway and Ryniker (6) have figured the extension of alveoli through chomata in *Fusulina* sp. that they identified erroneously as *Fusulinella euthysepta* Henbest, and I have seen numerous instances of such in *Triticites* (see pls. 34 and 35). The varved condition of alveolar chomata can hardly be considered harmonious with a hypothesis of prismatic keriotheca. Furthermore the spacing of the tubular alveoli and the manner of their bending in some instances make them appear unlike prisms (see pl. 35, figs. 1, 4, 8, 9, and 10).

Practically all the evidence relating to the character of the shell material can be interpreted as favoring each of the opposing hypothesis of origin—secreted versus agglutinate.

It is true that in well-preserved specimens, the alveolar walls in keriotheca and its variety diaphanotheca and the material composing epitheca is all granular (texture commonly 1 to 3 microns), and in some the grains sometimes vary in optical orientation. This might be taken to indicate that the grains were collected from the outside and cemented together, but unfortunately the grains fit rather too closely for agglutinate material which should resemble cobblestone work. Silica is sometimes found in fusulinid walls, but a secondary origin is certain in some and probable in the other instances. If the walls were agglutinate, the uniformly calcareous nature of the wall in all environments will have to be explained as an example of unusual selectivity not merely of a few species or a genus but of a whole family that lived in a great variety of environments. It is possible that the wall was originally composed of a very unstable material which developed granularity on replacement or change of state. Another possibility deserving careful consideration is that the shell substance was secreted by the animal as microscopic pellets at or nearly in place, and that granularity was an original characteristic of the shell material. In the absence of clear evidence, this explanation seems to have the fewest objections. A further possibility is that the shell material was originally structureless but be-

came granular after slight metamorphism. If this were true, greater variations in granularity and optical orientation should be found than exist.

Hayden (8) in 1909 discussed at length his belief that the alveoli of keriotheca were not blind pores ending at the tectum but actually opened at the outside. His notion has generally been discounted and the tectum taken to be an impervious and separate wall-element. In 1932 White (21), using *Triticites plummeri* as an example, revived Hayden's theory and illustrated what he considered external openings of the keriothecal pores. I have made a careful reexamination of this question covering several genera and have found that some of the evidence is tinged with ambiguity, but it generally supports Hayden. It may be argued that the pore openings to the exterior are the result of removal of tectum by abrasion or solution. I have examined the surface of well-preserved topotypes of *T. plummeri*, looking particularly at the furrows, and found keriothecal pores exposed in them, though generally not so clearly as on the ridges of the melon-like lobes. Large pores, smaller than septal pores but larger than alveoli, were found occasionally along the suture. These observations reduce the probability of denudation by abrasion but not by solution, for even though the furrows may escape abrasion, they would be exposed to the action of a solvent.

I have found numerous examples among species of *Triticites* of open keriothecal pores under chomata and the bases of septa. A few, less certain examples of such have been observed in specimens of *Fusulina* from Kansas. The numerous instances of alveoli continuing through the keriotheca, tectum, and epitheca, being particularly evident in chomata, are difficult to explain without considering them channels of communication possibly more for respiration, metabolism, and hormone transmission (if any) than for actual passage of sarcode masses. It appears that for the passage of sarcode material, and probably also for organules such as the nucleus, the tunnel was excavated and chomata erected to strengthen the shell structure where weakened by the tunnel. In many species of Fusulininae most of the diaphanothecal and septal pores in the central region of each volution were covered inside and out by epitheca after the tunnel was excavated. This seems to have been less true of *Triticites*.

Ordinarily it would be expected that if alveolar structure originated only for strengthening the shell, it would develop cellular alveoli such as in bone and woody tissue, which is a stronger structure than the honeycomb-like keriotheca. Labyrinthic structure is also more effective for strength and offers opportunities, though less favorable for communication. Two or more types of wall perforations in the same shell are common in various groups of Foraminifera, which circumstance nullifies an argument that the animal would develop pores like septal pores

in the spiral wall if it needed a porous wall. The regularity of the shape, spacing, and size of the keriothecal pores in *Fusulina* and *Triticites* seem to be analogous with, though finer than, pores in *Bradyina*.

Although these remarks on porosity of the spiral wall are intended to apply particularly to *Fusulina* and *Triticites*, the most typical genera of the Fusulinidae, they can be applied with modification to certain higher forms in which keriotheca becomes modified. Various photomicrographs by Colani (1), especially her Pl. 23, fig. 1, indicate external openings in the neoschwagerines illustrated.

Our understanding of the tectum is intimately connected with the understanding of the keriothecal pores. From a careful examination of the tectum of many specimens of *Fusulina* and *Triticites* at various magnifications up to 950 diameters it becomes evident that the tectum as a separate wall layer is generally most apparent at low magnifications. With

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EXPLANATION OF PLATE 34

FIGS. *1–4*—*Fusulina haworthi* Beede. Stained with methylene blue. *1*, ×250, Wall belonging to last volution of axial section in fig. *2*. The alveoli generally appear larger in proportion to the thickness of the alveolar walls than in this example. *2*, ×2.5, Three specimens in same section from lower Fort Scott limestone at Fort Scott, Kansas. The axial section agrees with Beede's original description of the species based on specimens from the same locality. Beede did not illustrate his specimens nor have his types been found, but the axial (particularly) and adjacent excentric cross-section may confidently be regarded as true *F. haworthi*. The lower cross-section may be one of *F. girtyi* (Dunbar and Condra), a common associate of *F. haworthi* in the lower Fort Scott limestone. *3*, ×250, Spiral wall and septum of the upper one of the excentric cross sections in fig. *2*. *4*, ×100, Keriotheca of another specimen from same locality. This shows the most characteristic appearance of keriotheca in *Fusulina*. Also stained with methylene blue. (p. 215)

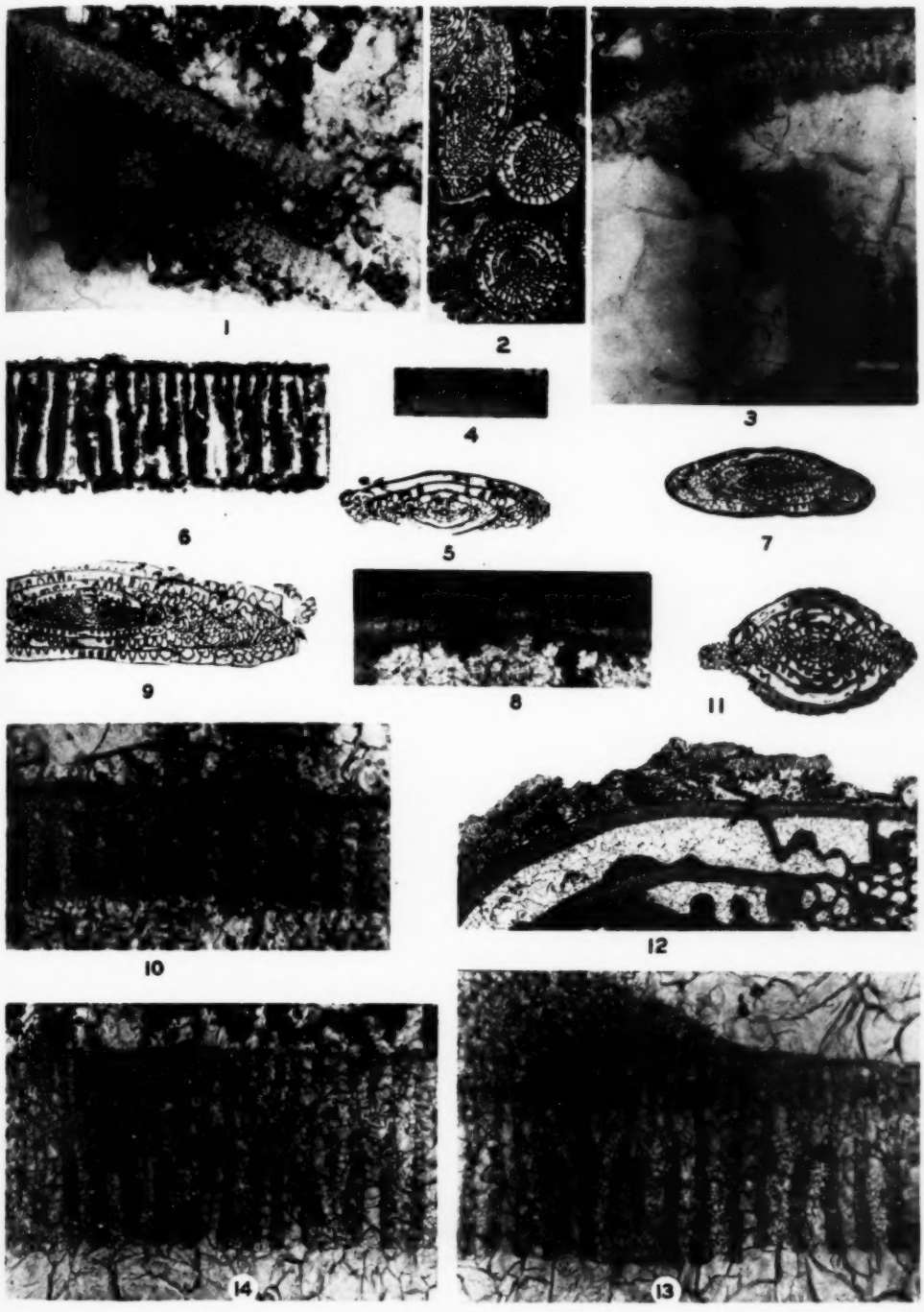
*5, 6*—*Triticites moorei* Dunbar and Condra. *5*, ×2.5, Axial section of specimen from the Cisco group (restricted), Brazos River region, north-central Texas (St. 678, slide C2, Henbest; Wallace Lee coll.). *6*, ×250, Spiral wall of same. Some of the alveoli dip from plane of section and present a false appearance of bifurcation. Other examples appear to be real bifurcation. Alveolar walls are thin relative to diameter of pores. Keriothecal structure about three times thicker than that of *F. haworthi*. Natural stain by limonite. (p. 222)

*7, 8*—*Fusulina* sp. from Holdenville formation, Oklahoma. Collected by John Skinner. Stained by methylene blue. *7*, ×2.5, Axial section. *8*, ×250, Spiral wall of penultimate volution. In this species, as in other *Fusulina*, the protheca is generally subordinate to epitheca in mass of shell substance except in the last volution or last few chambers, where protheca is the dominant shell layer. Note absence of tectum. (p. 215)

*9, 10*—*Parafusulina* sp. West Texas. *9*, ×2.5, Axial section. *10*, ×250, Spiral wall of same specimen. (p. 221)

*11–14*—*Triticites plummeri* Dunbar and Condra. (St. 528, slide A2, Henbest; Wallace Lee coll.) Cisco group (restricted), Brazos River region, north-central Texas. *11*, ×2.5, Axial section. *12*, ×25, Portion of same. Protheca (keriotheca) is here the dominant shell structure of the spiral wall. Tectum is most evident at this magnification. *13*, ×250, Portion of same specimen, spiral wall overlain by tectum and choma. Both of the latter are partly keriothecal in structure, but the tectum is a part of the choma and therefore epithecal in origin. *14*, ×250, Another location in same specimen. Alveoli extend through entire wall. The thin wall about 3 microns thick would presumably be called tectum, but it may actually be thin, dense tectorium. Not stained. (p. 217)

(All figures are unretouched photographs. Those of 250 diameters magnification were made by means of an apochromatic system, n.a. 0.65, and an achromatic condenser.)

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a well-adjusted oil-immersion system at 950 diameters (n.a. 1.25) an example of tectum in *Fusulina* sp. aff. *F. cylindrica* that appeared distinct at a magnification of 100 diameters (n.a. 0.25) could not be definitely distinguished except as an almost imperceptible increase in discoloration outward, and locally but not everywhere a slight decrease outward in size of the granules composing the diaphanotheca. Similar conditions are common also in other species of *Fusulina*. The mass effects of a combination of two or more features, such as very slight natural (?) staining and weathering suffered by the exterior of the shell during the occupation of the shell by the animal, may so greatly exaggerate the appearance of distinctness that a zone belonging to the protheca may by aid of diffraction, etc., appear to be a separate and distinct lamella. Probably more important factors still are two well-known optical effects: Constrictions at the top of the alveoli (see pl. 35, fig. 4) have the same effect as a line of closely-spaced dots that when viewed at a numerical aperture or magnification insufficient to resolve them, the diffraction bands around each dot overlap with those of the adjacent dots and give the mass effect of a solid line whose apparent thickness exceeds that of the object. The second optical effect is more commonly encountered than generally supposed. Two plane objects in imperfect optical contact (the usual condition at junctions of shell lamellae whose deposition took place at different times), when viewed from the edge, appear to have a dark contact zone if they are sufficiently fine in grain or contain enough impurities at or near the contact to absorb and reflect from view transmitted light, and if viewed under conditions of poor resolution. By means of a carefully adjusted and highly corrected lens system, I have often found that the latter optical effect is a common one. The distinctness of many apparently good examples of tectum have vanished when put to this test because of poor optical contact produced during the building of the shell or because of incipient cleavage caused by the harsh stresses of grinding the section. The zone of tectum, where covered by epitheca, is nearly always the first to fracture when a section is subjected to stresses.

Some specimens of *Fusulina* and rarely *Triticites* exhibit locally a tectum-like contact where epitheca lies against the inside of the spiral wall. Well-preserved specimens of *Fusulina* commonly contain a number of places where tectum is not in evidence at any magnification. In *Fusulina* particularly, the tectum of spiral walls covered by a later volution is much more distinct than that of the outside whorl. This feature is generally explained as the effect of erosion of the exposed surface after the shell was abandoned, but it is a fact disturbing to the concept of tectum as a separate layer that the tectum often seems to belong as much to tectorium lying on the outside of the spiral wall of inner volutions as to the keriotheca or its variety diaphanotheca.

Tectum (except that produced by optical illusions) may be absent entirely in *Fusiella* and *Schubertella*.

Seeing that the dark zone called tectum has such irregular distribution and heterogeneity in fusulinids, and even in single individuals of fusulinids where it has been normally recognized, we can well doubt that it is, as generally accepted, a distinct lamella belonging to the protheca. If we accept the evidence of its heterogeneity, the term is still worth retaining for use, though in a loose sense referring more to a zone than to a specific structure.

Whatever its nature and occurrence, tectum is generally perforate in *Triticites* and only locally closes the alveoli of keriotheca. It is apparently perforate in *Fusulina*, *Fusulinella*, and *Wedekindellina*.

It is evident that tectum is of at least two kinds, one a variety of epitheca and another an integral part of keriotheca. It is my notion that many examples of tectum consist of a preliminary covering, or first coat of epitheca, laid down on the spiral wall before the erection of a new chamber (somewhat like the callus of a snail), and of enclosed minute particles of debris and weathering products adhering to the outside of the shell. Wherever the outside of the keriotheca is discolored, abraded, or altered in any way such features would also contribute to

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EXPLANATION OF PLATE 35

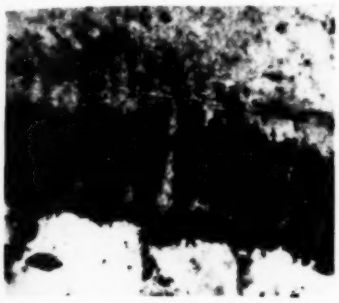
FIGS. *1, 2*—*Triticites beedei* Dunbar and Condra. (St. 635, slide A1, Henbest; Wallace Lee coll.) Cisco group (restricted), Brazos River region, Texas. *1*, ×250, Spiral wall and overlying choma showing alveoli in choma and local distribution of tectum. The tectum is unevenly distributed, in places imperforate but elsewhere perforate, and occurs in two layers, one of which belongs to the choma (epitheca). *2*, ×2.5, General view of same specimen. Staining natural, by limonite. (p. 217)

*3, 4*—*Triticites moorei* Dunbar and Condra. (St. 678, slide C3, Henbest; Wallace Lee coll.) Cisco group (restricted), Brazos River region, Texas. Staining natural, by limonite. *3*, ×2.5, Equatorial section. *4*, ×250, Spiral wall at meridional suture. External constrictions of alveoli common in *Triticites* are well shown in this view. At low magnifications this falsely appears as a separate wall structure and imperforate. Alveolus against front of septum is large and open throughout. (p. 217)

*5, 6*—*Triticites secalicus* (Say). (St. 644, slide 4, Henbest; Wallace Lee coll.) Cisco group (restricted), Brazos River region, Texas. *5*, ×2.5, General view of equatorial section. *6*, ×250, Spiral wall of same specimen showing absence of tectum. Long, slender, closely spaced alveoli are common in later volutions of this species. (p. 217)

*7–10*—*Triticites moorei* Dunbar and Condra. (St. 678, slide D2, Henbest; Wallace Lee coll.) Cisco group (restricted), Brazos River region, Texas. *7*, ×2.5, General view of axial section. Staining natural. *8*, ×250, Spiral wall of fourth and overlying alveolar choma of fifth volution. *9*, ×250, Same as fig. 8 but preceding volution. Because alveoli deviate from plane of section, fewer may have blind endings in choma than appears. Only structure in position of tectum is zone of constrictions in alveoli at outer edge of keriotheca. *10*, ×375 (approx.), Proloculum and chomata of first and second volutions photographed by combined darkfield and polarized illumination and analyzer showing alveolar character of primary and secondary walls of proloculum and first volution. Tectum entirely lacking. A recent discovery of alveoli in the prolocular wall of a specimen of *Fusulina* from Illinois encourages me to think that keriothecal wall-structure is a primitive and probably a characteristic feature of all Fusulinidae, but the force of such evidence is slightly limited by the fact that this juvenarium may be macrospheric. (Photographed by means of a modern American strain-free, 4 mm., achromatic objective of excellent definition.) (p. 222)

(All figures are unretouched photographs. Those of 250 diameters magnification were made by means of an apochromatic system, n.a. 0.65, and an achromatic condenser.)



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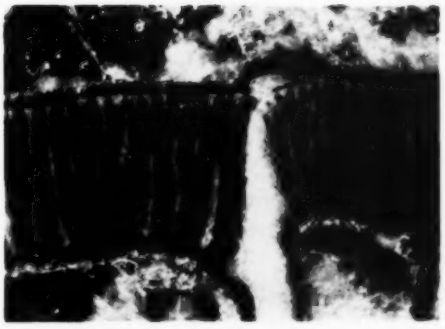

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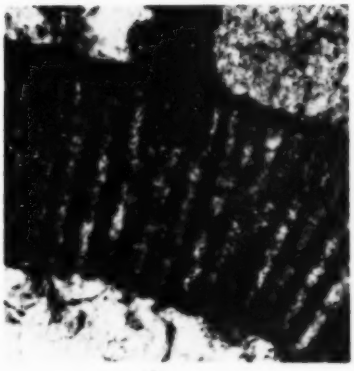

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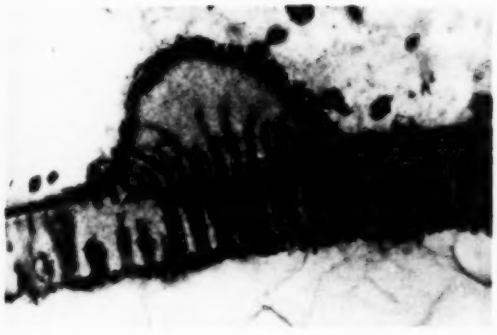

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the distinctiveness of the contact zone.

Some students of the Fusulinidae have described keriotheca as "porous or fibrous," apparently implying that these adjectives are synonymous or nearly so. I have not yet discovered any specimens in which fibrous structure occurs with or is equivalent to a keriothecal structure. Prismatic structure originating as a continuation of very fine, drusy calcite crystals that occasionally line the chambers has been found to penetrate shell walls. This prismatic crystallization of the shell-wall is probably more noticeable in diaphanotheca than in keriotheca. It seems to me that it is inappropriate to call a very fine keriothecal structure fibrous, if such is the intention, merely because in thin section keriotheca appears to be crossed by fine lines perpendicular to the wall or in some specimens by secondary prismatic crystals. This objection receives added force from the fact that, when finely resolved, the texture of the shell-material in species of *Triticites*, *Fusulina*, *Parafusulina*, etc., is granular. The fibrous appearance of the wall at low magnifications originates from viewing a vertical section without regard to depth or the third dimension.

## SIGNIFICANCE OF KERIOTHECA IN *FUSULINA*

Several important questions are provoked by the situation just described. It is necessary to reëxamine the system of classification now in general use to determine whether it harmonizes with historical information and with the present status of anatomical evidence. The wall-structure of the group typified by *Fusulina* must be distinguishable from that typified by *Triticites* and *Schwagerina* or the subfamily divisions will fall.

Attention should first be given to the shell-structure of *Fusulina cylindrica* Fischer, whose taxonomic position is critically important because it is the generic and family type and because its real wall-structure has been much studied, though generally misunderstood.

The case for the existence of a fusulinellid wall-structure in *Fusulina cylindrica* seems to be reasonably secure. Besides the evidences described in 1930 by Dunbar and Henbest (4), photographs published by Schellwien (19, pl. 13, figs. 1 and 2) of some of the topotypes of *F. cylindrica* from Mjatschkova that Möller used provide additional and very important data. These pictures bear unmistakable evidences of the wall-structure typified by *Fusulinella* and Middle Pennsylvanian fusulinids. The presence of diaphanotheca and widely distributed epitheca is not difficult to make out. The septa are deeply and regularly plicated, and the tectorium is not much thicker than the diaphanotheca. Accordingly, *F. cylindrica* differs from *Fusulinella* by having deeply and regularly plicated septa and a nearly equal thickness of tectorium and diaphanotheca and differs from *Triticites*, etc., by lacking thick keriotheca. It is a curious fact that Schell-

wien evidently understood the real character of *Fusulina cylindrica* but did not make any attempt to correct the effects of Möller's error. The results of later investigations on topotypes of *F. cylindrica* by Lee, Dunbar, and the author agree with the evidence so fortunately recorded by Schellwien. A critical comparison of Schellwien's published photographs with Möller's illustrations will leave little doubt that Schellwien had two of Möller's topotypes, because defects and other gross features of the specimens figured by each are identical. Lee's observations on this point (12, p. 34, etc.) indicate that he had previously reached a similar conclusion. Since the writing of this paper Thompson, and Dunbar and Henbest have prepared separate papers dealing with the nature of *F. cylindrica*, and I understand that the conclusions are in essential agreement with those herein expressed (22).

Although it can hardly be doubted that *Fusulina cylindrica* possessed diaphanotheca, we may never be able to know except by inference that its diaphanotheca has a fine honeycomb structure, because most of the specimens exhibit little detail beyond the threefold fusulinellid wall structure. This point will be further investigated by the studies cited above. The two different collections of topotypes that I have seen occur in a white coquina in which the shell material has been coated with lime—possibly through the agency of Algae—and recrystallized. The internal characteristics of the shells can be determined in a general way without difficulty, but the very minute details are obscure. In some of the topotypes belonging to the U. S. National Museum I have observed very faint and rather uncertain indications of alveoli. Lee has observed fine honeycomb structure in a closely related species and in an identical form from North China, and I have resolved fine keriotheca in two American species of *Fusulina* from Oklahoma and Missouri, one of which is very closely related to topotypical *F. cylindrica* from Mjatschkova. The assortment of species of *Fusulina* in which keriothecal structure has been found is so great that they can hardly be considered non-representative.

The number of Lower and Middle Pennsylvanian genera in which keriothecal structure has been reported is sufficiently large to make it appear probable that all members of the subfamily Fusulininae have alveolar diaphanotheca. The fact must not be forgotten, however, that the presence of alveolar diaphanotheca has not yet been satisfactorily demonstrated in some of the more primitive genera. A recent discovery of a specimen of *Triticites moorei* Dunbar and Condra from the Cisco group (restricted) of the Brazos River region, Texas, that exhibits keriothecal chomata in the first volution and alveolar protheca in the proloculum adds strong evidence that keriotheca, or varieties thereof, is characteristic of the family (cf. pl. 35, fig. 10).

These circumstances call the present mode of classification to trial because its basic criterion as applied to Pennsylvanian Fusulinidae is no

longer valid. It is now necessary to determine whether the scheme is phylogenetically correct in spite of the fact that, as previously defined, the criteria are no longer distinctive. If the scheme is sound, in spite of the mistake in mode of definition, the necessity arises for revising the old or discovering new principles of differentiation. If unsound, the subfamilies Fusulininae and Schwagerininae will have to be merged under the name Fusulininae.

A brief comparison of the anatomy of the Pennsylvanian Fusulinidae will help to decide the issue. The genus *Staffella*, considered the most primitive of the family, has a generalized form (spherical) and has a fusulinellid wall; its septa are nonplicated; and its wall-structure is comparatively massive. The space for sarcode is greatly reduced by extensive and thick tectorium. *Fusulinella* is similarly constructed but is fusiform instead of spherical. One of the higher species has irregularly but deeply plicated septa in the last one or two volutions. *Wedekindellina* can hardly be distinguished from *Fusulinella* by any one anatomical feature, but *Wedekindellina* has more closely-spaced septa, closer volutions, and thicker tectorium in proportion to its size. Its walls, therefore, are unusually massive and chamber space very small. *Nummulostegina* (=*Orobias*) resembles *Staffella* but is lenticular and may be slightly asymmetrical, at least in some species. *Schubertella* is not yet well understood, but Lee, Chen, and Chu (14) have held that it is a distinct form and not merely immature *Fusulinella*. It has been suggested that *Schubertella* may be an alternate generation of *Fusulinella* or *Staffella*. The wall-structure is probably fusulinellid but thin; the chambers are few and large; and as a whole its chambers and external form are like a specimen of *Glyphostomella* that had been axially extended just enough to make its shape slightly and unevenly fusiform (23).

Lee, Chen, and Chu (14) have been unable to distinguish a three fold wall-structure in three species of *Schubertella* from China, thereby agreeing with the original description of the genus by Staff and Wedekind, though with some misgivings, it would appear. Galloway (5) reports not only a keriothecal, fusulinellid wall structure in *Schubertella* but presents definite measurements of the porous texture.

*Fusulina* has an unmistakable fusulinellid wall, and the macrospheric juvenarium of earlier species is in every respect fusulinellid. It differs from all but one known species of *Fusulinella* by having regularly plicated septa, less massive tectorium, and greater variety of form and size. *Boultonia* apparently has the anatomy of *Fusulina* but is peculiar in having an endothyroid juvenarium, a distinction of uncertain value. *Fusiella*, *Boultonia*, and *Schubertella* are not yet well understood, as only a few rather poorly preserved species of these genera are known. *Fusiella* is very small, has an endothyroid juvenarium, and, according to its authors the diaphan-

otheca is very thin to indistinct.

Various authors have remarked on the absence of clearly distinguishable, threefold wall-structure in *Fusiella*, *Boultonia*, and *Schubertella*. Without having had an opportunity to examine authentic examples of these genera, I am inclined to think it likely that they are closely related to *Fusulina* and *Fusulinella*, and possess walls composed of diaphanotheca with very little, if any, tectorium and little or no tectum of any kind. Such wall-structure is not uncommonly found in immature *Fusulina*. In the absence of more definite information, it is hardly possible to make a good case for erecting a special subfamily to receive these genera.

Accordingly the more characteristic genera of the Lower and Middle Pennsylvanian (*Fusulina*, *Fusulinella*, *Wedekindellina*, *Staffella*, and *Nummulostegina*) have in common the diaphanoetheca as redefined in this paper. The mere presence of tectorium is not peculiar to the group, but insofar as the tectorium is a prominent constituent of the shell wall in all but two or three genera of doubtful position, it becomes as such a second distinguishing feature. The fact that the Fusulininae are generally small is corroborative evidence, though of rather limited value. The third important anatomical trait is the very fine texture of the keriotheca. The texture is so fine and the porous layer so thin in comparison with the keriothecal layer in the Schwagerininae that it seems worth while to retain the term "diaphanotheca" for this kind of keriotheca. Obviously, the term "diaphanotheca" can no longer signify, as originally proposed, a layer that is actually structureless.

The shell wall of the Schwagerininae is characterized, in contrast with the Fusulininae, by a thick keriotheca in which the alveoli are relatively large and easily visible in ordinary preservation (see pls. 34 and 35). The alveolar walls are commonly thin in proportion to the diameter of the alveoli, while in the Fusulininae the opposite is generally true. Secondary deposits are much less important in the shell structure than the primary layer, except in a few of the earliest species of *Triticites*. Early in the history of *Triticites*, keriotheca becomes, and thereafter remains, the dominant shell layer, and epithecal deposits become inconspicuous, thin, and concentrated principally in the chomata. In later species of *Triticites* and later genera of Schwagerininae the chomata diminish in size until they are either absent or restricted to the juvenarium.

Very strong circumstantial evidence favoring continued separation of Fusulininae from the Schwagerininae exists in the historical relationships of the two groups. The present records indicate that the Fusulininae ranged from Upper Mississippian through Lower and Middle Pennsylvanian. In Upper Pennsylvanian they become prominent members of the fauna. The Schwagerininae probably evolved from *Fusulina* in Middle Pennsylvanian time,

but no definite record of this subfamily earlier than Upper Pennsylvanian has yet been described. After the extinction of the dominant stock of the Fusulininae (culminating in *Fusulina*), the dominance passed abruptly over to *Triticites*. It now seems that everywhere the very prolific and highly evolved genus *Fusulina* came to an abrupt end and was followed after an interval in most places by a prolific genus, *Triticites*, whose earliest species were already highly evolved forms. Conservative species of *Staffella* and *Fusulinella* may have survived *Fusulina*, but adequate confirmation of that needs to be presented. I regard the almost world-wide hiatus between *Fusulina* and *Triticites*—the two most closely related and morphologically typical genera of these two subfamilies—as highly significant of subfamilial distinction, even though I fully expect that stratigraphic and biologic connections will eventually be found.

Arguments favoring the merging of the subfamilies Fusulininae and Schwagerininae (becoming, in that case, Fusulininae, as this term has priority) may be proposed. An important one is that in certain respects *Fusulina* grades anatomically into *Triticites* and that some species, such as *T. irregularis* (Schellwien and Staff), "fourth form" of White (21), are not easy to distinguish from some very close relatives of *F. cylindrica*. A further difficulty appears in the fact that *T. irregularis*, one of the earliest *Triticites* in America, makes a rather poor antecedent for. *T. secalicus*, *T. ventricosus*, and *T. plummeri*. So one may think either that the group *Triticites* is polyphyletic, having descended from two or more species of *Fusulina*, or that, if monophyletic, the genus must have been in existence long enough to divide into the discrete species *T. irregularis* and *T. secalicus* before our record begins. Much could be said for both of these views, but the practical aspects of the problem prejudice us in favor of treating a group as monophyletic until strong or generally acceptable evidence proves the contrary. The practice will undoubtedly take the trend of removing foreign elements as they are discovered. Though differing among themselves, species of *Triticites* have in common a coarse-textured keriotheca, whose thickness generally exceeds that of the combined protheca and epitheca of Fusulininae. If one considered the genera *Fusulina* and *Triticites* as composites, or arrayed their component species for sake of comparison, the intergradational features between these two most typical and most closely related genera of their respective subfamilies would turn out to have particular rather than general significance.

In answer to these arguments for merging the subfamilies, it may be said that among all organisms a line of intergrading species between parent and descendant subfamilies is probably the rule rather than the exception, except where extreme and well-protected mutations have occurred. It is almost platitudinous to say that many of our taxonomic discriminations are in large measure

arbitrary, the offspring of convenience. As our records become more complete, the arbitrary nature of most taxonomic schemes becomes more apparent. This, however, can hardly be used as an excuse for making unnecessarily arbitrary discriminations, because historical and scientific accuracy must have more weight in classification than convenience and usefulness.

Even if a complete, gradational series from *Fusulina* to *Triticites* were established, that fact alone would be insufficient cause for merging the two subfamilies represented, because a subfamily is created to represent group relationships and history and can have a definite place of beginning only if it originates by an extremely revolutionary change and can have a definite end only if it leaves no gradually evolved descendants. Under these conditions, most subfamilies probably have an indefinite beginning, and those leaving descendants have a similar ending; so the subfamily Fusulininae does not differ in this respect from other subfamilies whose historical record is unusually complete.

No single line of evidence suffices to solve our problem. The combination of several lines, each leading in the same direction but individually incomplete, indicates that the emended Dunbar and Condra classification represents most closely the phylogenetic relationships as they are now understood. The following revised definition of the two Pennsylvanian subfamilies is therefore proposed:

## Family FUSULINIDAE

### Subfamily FUSULININAE Rhumbler, 1895 (em. Dunbar and Henbest, 1930)

Spherical and lenticular to most typically fusiform, rarely cylindrical. Small to medium size. Septa plane to deeply and regularly plicated, certainly porous in some and probably in all genera. Proloculum generally small. Juvenarium differs in symmetry, distinctness, and orientation, variously according to genus, species and to generation within a species. Pair of chomata present in all genera and generally well developed. Spiral wall in advanced genera composed of two distinct layers, not including the heterogeneous outer, often indistinct very thin, dark zone (tectum): a primary inner clear thin layer (commonly 10 to 15 microns, rarely 20 microns thick in higher genera) having a very fine, usually obscure honeycomb structure (diaphanotheca); and a slightly darker secondary lining of the chamber walls and floor (tectorium), which usually exceeds the total thickness of the primary wall. Spiral wall of a few primitive side issues of the subfamily stock has uncertain composition, but in later genera epitheca is the dominant wall material.

Especially characteristic of and mainly restricted to Lower and Middle Pennsylvanian but probably ranging from Mississippian to Permian(?).

Genera included: *Nummulostegina, Staffella, Schubertella, Fusulinella, Fusulina, Wedekindellina, Boultonia, Fusiella, Yangchienia, Sphaerulina.* (The relationships of the last four genera are not yet well established.)

### Subfamily SCHWAGERININAE Dunbar and Henbest, 1930

Typically fusiform to subcylindrical; some ventricose to spherical. Medium to very large size. Septa generally deeply and regularly plicated except in *Schwa-*

*gerina*, wherein degree of plication varies greatly. Possesses generally a single tunnel, but two higher genera develop secondary tunnels (*Polydiexodina*) or vaulted passages between alternate chambers under the septal folds (*Parafusulina*). Proloculum medium to very large. Juvenarium generally symmetrical in macrospheric individuals, and a distinct phase of shell building in *Schwagerina;* in other genera it generally grades into adult morphology, except in the microspheric stage, which is represented by an endothyroid juvenarium. Chomata present in adult stage of *Triticites*, but later genera have chomata only in the juvenarium or none at all. Septa generally, if not always, porous, at least in the later septa. Spiral wall composed of three elements, "tectum" zone, keriotheca, and subordinate to indistinct amounts of *epitheca*. In contrast with the Fusulininae, the keriotheca in all genera but *Paleofusulina* is coarsely textured and commonly ranges from 30 to 100 microns in thickness. In all genera keriotheca is obviously the dominant element of the shell wall, tectorium being generally a subordinate to inconsequential element or highly diffused and hardly recognizable as a distinct structure. Only a few species of *Triticites* are likely to be confused with *Fusulina*.

Upper Pennsylvanian to Upper Permian.

These diagnoses are more indefinite and more complicated than the originals, but since there is no single anatomical feature that is entirely exclusive, a combination of criteria is necessary. Some trouble will be encountered in generic identification of possible new discoveries of a more generalized variety of *Triticites irregularis* or of a species similar in general structure to *Fusulina cylindrica* but having unusually thick and coarsely textured diaphanotheca.

### SIMPLIFIED CLASSIFICATION

Passing reference has been made above to a simplified classification that was adopted by White (21). This classification involved the merging of several genera. The exact extent of the merger was not definitely stated, but those genera with which he dealt in the descriptive portion of his report are indicated in the following list:

***Fusulina.***—*Fusulina* Fischer (not Möller), *Wedekindellina* Dunbar and Henbest. The status of *Beedeina*, *Fusulinella*, *Fusiella*, *Boultonia*, etc. was not indicated.)

***Triticites.***—*Triticites* Girty, *Pseudofusulina* Dunbar and Skinner (now *Schwagerina*, s. s.), *Parafusulina* Dunbar and Skinner. (If this merger is carried out, the name *Triticites* becomes a synonym of *Schwagerina*, s. s., since the latter has priority by 27 years. Presumably *Polydiexodina* and *Paleofusulina*? should be included.)

***Schwagerina***—(of authors, now *Pseudofusulina* Dunbar and Skinner).—No other genus combined with this one.

It is highly probable that this simplified classification will be favorably received by those whose only interest in fusulinids is for stratigraphic purposes. The author's purpose (see White, 1932, p. 5) in reducing the number of names was to avoid further complication in nomenclature, to simplify the nomenclature already in use, and to leave for the initiative of the individual worker such fine distinctions as those which are not based on easily and generally recognizable differences. No one can disagree with the first two purposes here expressed. It is my belief, how-

ever, that the measures taken to promote these purposes are self-defeating.

The effects of merging generic names, assuming that the genera are based on valid though possibly involved historical and anatomical evidence, are several. The number of species included in the single genus is extended. The stratigraphic range of the composite genus must be extended to equal that of the merged genera. The historical and phylogenetic connotations of the separate generic names are obliterated from the taxonomic scheme, unless the several merged genera are treated and quoted as subgenera.

At first thought the reduction in number of generic units appears to be a real simplification, but unfortunately the combination of several more or less different units into one increases the range and complexity of the composite unit without gaining anything in precision. In the generally accepted scheme of classification, the presence of a form identifiable as *Triticites* in a collection would indicate Upper Pennsylvanian to basal Permian age. This genus is rather easy to identify. In the simplified classification, the presence of genus "*Triticites*" would indicate any age from and including Upper Pennsylvanian through Middle and possibly Upper Permian; and because of its diversity the larger, composite genus would be harder to define exclusively and comprehensively and it would be harder to learn than its component units severally. With genera of such broad scope, a fossil, to have a proximate or a particular age-significance, would have to be identified specifically. A dilemma confronts the stratigrapher here. If he attempts a specific identification, he thereby pretends a precision that does not exist, as he may not have enough experience with this special group to eliminate confusion of similar species. If he identifies the form merely as "*Triticites* (of White)" to avoid good chances of a taxonomic error, he has then accomplished only a too general and a useless identification.

The specialist on the group will undoubtedly refuse to accept a mode of taxonomy that inadequately represents the results of his work. It is no less important from a scientific viewpoint that the taxonomy suit the convenience of the specialist than that it be convenient for him who makes practical use of the information. We expect the specialist to be penetrating and accurate and to refine learning, but conflict always arises over the mode of expressing his discovery in terms of common experience. The specialist insists on accuracy and comprehensiveness, and the non-specialist urges popularization.

This very issue is one of growing importance in paleontology and stratigraphy. In the last few years, the paleontological record has grown so extensively that the stratigrapher is finding it increasingly difficult to keep in touch with advances in paleontology. It is probably impossible to lay down a single principle that is adequate for solving this prob-

lem. The retention of old, familiar names in their original significance, whether valid or invalid, separately for use in general geology has been suggested. Another scheme might serve the same purpose by erecting a separate simplified nomenclature for general use. It is hardly necessary to point out the self-evident objections to these schemes.

It is my belief that the problem can best be solved not by lumping distinguishable genera for sake of simplification, but by encouraging a more general use of genera and generic names alone without attempts at specific designations. Such encouragement is especially appropriate when dealing with a highly specialized or very prolific group, such as the Fusulinidae, but is less so with others. The students of today who learn the ranges and manner of identification of the common genera of North American fusulinids gain more useful knowledge for stratigraphic purposes than the student of 15 years ago who learned all of the species and genera then described.

Returning to the question of lumping fusulinid genera, one further advantage of detailed generic divisions in this family is that the taxonomic grades of *family*, *subfamily*, *genus*, and *species* in the Dunbar and Condra system furnish a very convenient and evenly integrated set of stratigraphic and phylogenetic values.

In conclusion on this point, it is my belief that anatomical evidence, checked against the stratigraphic record, rather than convenience for stratigraphy, should determine the taxonomy. This principle probably works ultimately for the greatest advantage of all concerned.

REFERENCES


1. COLANI, M., Nouvelle contribution a l'étude des fusulinidés de l'Extreme-Orient: *Serv. géol. Indochine, Mém.*, vol. 11, 1929.
2. DUNBAR, C. O., and CONDRA, G. E., The Fusulinidae of the Pennsylvanian system in Nebraska: *Nebraska Geol. Survey*, 2d ser., Bull. 2, 1927.
3. DUNBAR, C. O., "Fusulinidae" in Cushman's "*Foraminifera . . .*," 2d ed., *Cushman Lab. Foram. Research*, Sharon, Mass., 1933.
4. DUNBAR, C. O., and HENBEST, L. G., The fusulinid genera *Fusulina*, *Fusulinella*, and *Wedekindella: Am. Jour. Sci.*, 5th ser., vol. 20, pp. 357–365, 1930.
5. GALLOWAY, J. J., *A manual of Foraminifera*, The Principia Press, Bloomington, Indiana, 1933.
6. GALLOWAY, J. J., and RYNIKER, C., Foraminifera from the Atoka formation of Oklahoma: *Oklahoma Geol. Survey, Circular* 21, 1930.
7. GÜBLER, J., Structure et secrétion du test des fusulinidés: *Ann. Protistologie*, vol. 4, October, 1934.
8. HAYDEN, H. H., Fusulinidae from Afghanistan: *Geol. Survey India, Records*, vol. 38, pp. 250–256, pls. 17–22, 1909.
9. HENBEST, L. G., Fusulinellas from the Stonefort limestone member of the Tradewater formation: *Jour. Paleontology*, vol. 2, pp. 70–85, 1928.
10. ——, Keriothecal wall structure in *Fusulina;* its significance and resolution by selective stains (abstract): *Geol. Soc. Am., Proc.* 1933, p. 353, 1934.
11. ——, A new term for the youthful stage of foraminiferal shells: *Science*, n.s., vol. 79, pp. 363, 364, 1934.
12. LEE, J. S., Fusulinidae of North China: *Geol. Survey China, Paleontologica Sinica*, ser. B, vol. 4, fasc. 1, 1927.
13. ——, Taxonomic criteria of Fusulinidae with notes on seven new Permian genera: *Nat Research Inst. Geology [China], Mem.*, no. 14, pp. 1–33, 1933.
14. LEE, J. S., CHEN, S., and CHU, S., The Huanglung limestone and its fauna: *Nat. Research Inst. Geology [China], Mem.*, no. 9, pp. 85–144, 1930.
15. MÖLLER, VALERIAN VON, Ueber Fusulinen und ähnliche Foraminiferen-Formen des russischen Kohlenkalkes: *Neues Jahrb.*, Jahrg. 1877, pp. 138–146.
16. ——, Die spiral-gewundenen Foraminiferen des russischen Kohlenkalks: *Acad.*

*Imp. Sci. St. Pétersbourg, Mém.*, ser. 7, vol. 25, no. 9, 1878.

17. OZAWA, Y., On the classification of the family Fusulinidae: *Tokyo Imp. Univ., Fac. Sci., Jour.*, vol. 45, art. 4, pp. 1–26, 1925.
18. ——, "Fusulinidae" in Cushman's "*Foraminifera . . . :*" *Cushman Lab. Foram. Research*, Sharon, Mass.
19. SCHELLWIEN, ERNST, Monographie der Fusulinen: Teil I, Die Fusulinen des russisch-arktischen Meeresgebietes: *Paleontographica*, Band 55, pp. 145–194, 1908.
20. STAFF, HANS VON, and WEDEKIND, R., Der oberkarbone Foraminiferen-Sapropelit Spitzbergens: *Geol. Inst. Upsala, Bull.*, vol. 10, pp. 81–123, 1910.
21. WHITE, M. P., Some Texas Fusulinidae: *Univ. Texas, Bull.* 3211, pp. 1–106, 1932.
22. THOMPSON, M. L., The genotype of *Fusulina* s. s.: *Am. Jour. Sci.*, 5th ser., vol. 32, pp. 287–291. 1936.
23. ——, Fusulinids of the subfamily Schubertellinae: *Jour. Paleontology*, vol. 11, pp. 118–125, 1937.

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# *MULTISOLENIA*, A NEW GENUS OF PALEOZOIC CORALS

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ABSTRACT

The genus *Multisolenia* is created to include a colonial coral from the Silurian of the Lake Timiskaming district, in northern Ontario. This coral presents a hitherto unrecognized combination of characteristics. Its corallum, corallites, and septa resemble the Chaetetina of the Schistocoralla, but its corallites are connected by many solenia, as in the Alcyonaria.

The new genus of corals herein described is based on the study of a single specimen from the Silurian Lockport formation on Mann Island (formerly called Burnt Island), in Lake Timiskaming, in northern Ontario. The specimen was given to me for description by the late Dr. W. A. Parks, who found it among a stromatoporoid collection made for the University of Toronto by Mr. John Townsend in 1900. For comments on this peculiar bryozoan-like coral I am indebted to Dr. R. S. Bassler.

The specimen is of stratigraphic interest because it came from an outlier of Silurian rocks on the pre-Cambrian. The nearest Silurian outcrops are in Manitoulin Island, to the southwest, and on the shores of Hudson Bay, to the north. The outlier was probably preserved because of the down-dropping of a large segment of pre-Cambrian and overlying sedimentary rocks in the Lake Timiskaming rift fault.

In outward appearance the specimen greatly resembles a small stromatoporoid. Its microscopic structure suggests a bryozoan of the genus *Monotrypa* on whose walls spurlike projections have developed. These spiny processes, however, are septal structures, the presence of which leaves no doubt that the fossil is a coral.

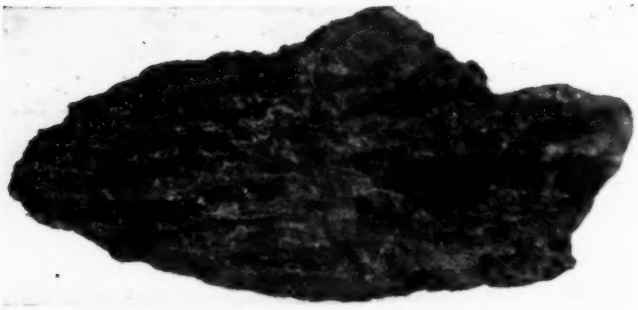
The general shape of the corallum, the size and meandering nature of the corallites, and the spiny septa suggest relationship to the *Chaetetes radians* group of the Carboniferous (1, 2, 3, 4); but numerous large pore-like solenia or connecting tubes rule out *Chaetetes* and suggest the Alcyonaria (5). The evidence presented by the new coral does not warrant placing it in any recognized group. It is here referred to a new genus upon which, eventually, may be based a new order or even a new subclass.

## SYSTEMATIC DESCRIPTION

Genus MULTISOLENIA Fritz, n. gen.

The corallum consists of a stratiform mass, probably cerioid, but the preservation of the specimen upon which the genus is based is too imperfect to assure this fact. The corallites are very small, prismatic or somewhat rounded, with thin walls in places suggesting a finely porous or granular structure and provided with spiny septal plates acting as agents in the process of simple fission. Solenia are numerous.

Genotype: *Multisolenia tortuosa* Fritz, n. sp.



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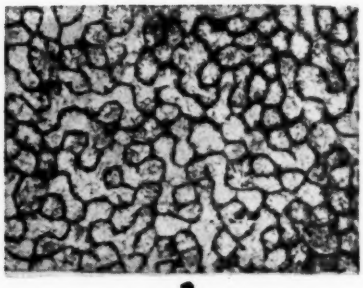

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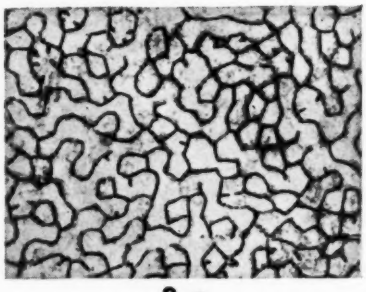

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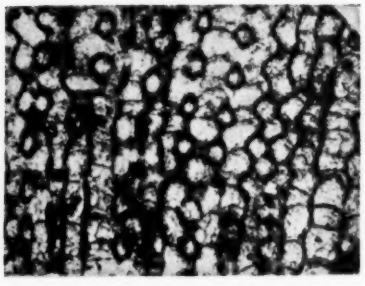

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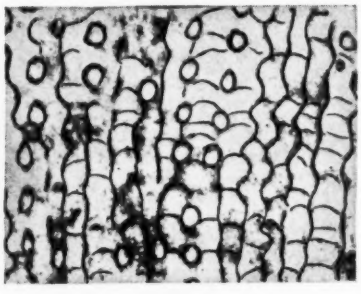

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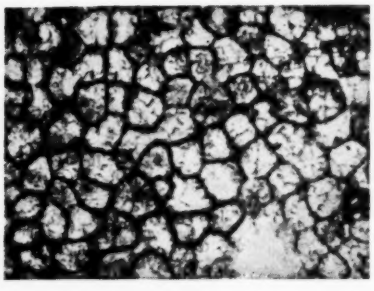

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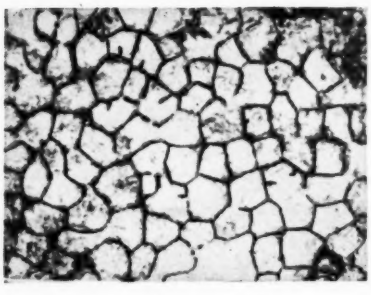

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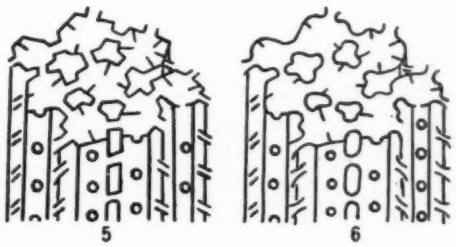
MULTISOLENIA TORTUOSA Fritz, n. sp.
Text-figures 1–6

The corallum consists of a stratiform mass more than 70 mm. wide and 35 mm. thick. The corallites are irregularly prismatic to rounded, with thin, slightly porous or granular walls. They range in diameter from 0.25 mm. to 0.6 mm. Multiplication is by simple fission, the septa acting as agents in this process. Multiplication appears to have taken place very frequently and to have been completed within the space enclosed by two tabulae. The septa are in all stages of development, from mere thickenings in the walls to the last stage, in which the septum has grown directly across the corallite or has grown only halfway across and met its component from the other side. Septa range in number from one to six, three being common.

Cross sections and polished surfaces across the corallum show many solenia or connecting tubes, which may be traced clearly from one corallite to another. The solenia are relatively large, measuring 0.25 mm. in width. They seem to be widest near the corallites and narrowest about midway along their length. The abundance of these tubes tends to produce in cross sections a particularly tortuous or meandering appearance, which feature has suggested the specific name.

Vertical sections and polished vertical surfaces show that the tabulae are closely spaced, with a tendency to arch upward. The distance between the tabulae is, as a rule, about equal to the width of a corallite, but may be only half or twice that width. Vertical sections show very clearly




FIGS. *5*, *6*.—*Multisolenia tortuosa* Fritz, n. gen. and sp., diagrams of structure. *5*, Purely diagrammatic view showing prismatic corallites, numerous solenia, and septa in various stages of development. *6*, An attempt to show the tortuous, meandering nature of the corallites.

the cut ends of the solenia, large porelike structures 0.25 mm. in diameter. The solenia are very numerous and regularly spaced, generally two to the millimeter measured vertically along a wall. In other parts of the section the tubelike character of the solenia is clearly revealed.

Occurrence: Silurian, Lockport formation; Mann Island (Burnt Island), Lake Timiskaming, Ontario.

Holotype: Royal Ontario Mus. Paleontology 1154.

*Addendum.*—The illustrations of a recent paper by Oakley (6) strongly suggest bryozoan affinities for *Chaetetes akpatokensis*, an Ordovician species from Atpatok Island, Ungava Bay, Quebec. The absence of septa is a strong argument against the coralline nature of this species, although septa are absent in the Chazy genus *Lamottia* described by Raymond (7). I am tentatively referring to the genus *Dianulites*, the bryozoan na-

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FIGS. *1–4a*—*Multisolenia tortuosa* Fritz, n. gen. and sp., holotype, Roy. Ontario Mus. Paleont. 1154. *1*, External view, ×1. *2*, *2a*, Tangential section, without and with retouching, ×10, showing numerous solenia, spiny septa, and fission at its height; the meandering nature of the corallites is well shown; R.O.M.P. micro. slide 1754. *3*, *3a*, Vertical section, without and with retouching, ×10, showing the regularly spaced solenia and slightly arched tabulae; the cut ends of the solenia show up particularly well as pores; R.O.M.P. micro. slide 1755. *4*, *4a*, Tangential section, without and with retouching, ×10, representing a quiescent period in the division of the corallites; R.O.M.P. micro. slide 1753. (p. 233)

ture of which has not yet been disputed so far as I am aware, an Ordovician species from Seven Islands, in the Gulf of St. Lawrence, which I consider to be a bryozoan and which very strongly resembles *Chaetetes akpatokensis*. It may be noted, however, that the genus *Dianulites* shows the porous wall-structure faintly suggested in *Multisolenia tortuosa* and well shown in *Chaetetes akpatokensis*. The only other Ordovician species referred to *Chaetetes* is *C. perantiquus* Whiteaves, whose original figures (8) very strongly indicate relationships with the Bryozoa.

REFERENCES

1. Smith, Stanley, and Lang, W. D., *Annals of Nat. History*, vol. 5, ser. 10, pp. 188–191, 1930.
2. Okulitch, V. J., *Am. Jour. Sci.*, vol. 32, p. 379, 1936.
3. Smyth, L. B., *Geol. Mag.*, vol. 62, pp. 319-322, pls. 14, 15, 1925.
4. Heritsch, F., *Am. Jour. Sci.*, vol. 25, p. 257, 1933.
5. Okulitch, V. J., *Am. Jour. Sci.*, vol. 32, p. 363, 1936.
6. Oakley, K. P., *Geol. Mag.*, vol. 73, pp. 440–444, 1936.
7. Raymond, P. E., *Vermont State Geologist, 14th Rept., 1923–24*, pp. 72–76, 1924.
8. Whiteaves, J. F., *Canada Geol. Survey, Paleozoic fossils*, vol. 3, p. 238, 1884.

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 3, PP. 235–240, 23 TEXT-FIGS., APRIL, 1937

# AN OPHIURAN FROM THE BYRAM MARL (OLIGOCENE) OF MISSISSIPPI

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ABSTRACT

Arm and disk plates of *Amphiophiura oligocenica*, n. sp., are described from the Byram marl (Oligocene) of Mississippi.

The first paleontologist to be attracted by what nearly a century later was named the Byram marl was Lesueur, when in 1829 he figured five plates of fossils from the Vicksburg group, failing however to name or describe any of them. It was not until 1834 that the first actual description of these fossils appeared (1). In 1922 Cooke (2) listed 134 mollusks, 5 corals and 2 echinoderms from the Byram marl of Mississippi, and in an accompanying paper, Cushman described the Foraminifera from the type locality of the Byram. The present article deals with ophiuran plates found in a small lot of washed marl collected in 1934 by P. Bunton from the banks of Pearl River at Byram, Mississippi.

The Byram marl is the uppermost formation of the Vicksburg group and is Oligocene in age. According to Cooke (3), at Byram, on the Pearl River, Hinds County, Mississippi,

> broad ledges of indurated glauconitic marl alternating with softer beds of green clay rise about 10 feet above low-water mark. The rock is abundantly fossiliferous, and most of the fossils are contained in pockets of softer marl.

Cooke does not draw any conclusions from the mollusks as to the depth at which these deposits were laid down, but Cushman (4) writes:

> From the comparison of the records for those species which are found fossil in the marl at Byram and also living in the Indo-Pacific region it is evident that the Bryam marl was deposited in comparatively shallow water (10 to 25 fathoms).

A living species of the genus *Amphiophiura*, to which is assigned the ophiuran here described, has a known depth range of 10 to 3353 fathoms (5).

Although ophiuran remains are known from the Cretaceous, the only species that have heretofore been reported from the Tertiary of North America are confined to beds of Miocene age. Even in these less than five genera are represented. Therefore this new Oligocene ophiuran from Mississippi is the first species of this age to be reported from North America or elsewhere in the world.

All but two of the known Tertiary ophiurans fall into four families—the Amphiuridae, the Ophiodermatidae, the Hemieuryalidae, and the Ophiolepididae. The two exceptions are not easily classified. The first three of these families are represented each by a single fossil species and the last by two species. The new Oligocene specimen herein described adds an-

other species to the family Ophiolepididae, giving it more representatives during Tertiary time than any other single family, and bringing the number of ophiurans reported from the Tertiary to eight species.

It is the presence of the comb plate that places this Oligocene species in the family Ophiolepididae, which, according to H. L. Clark (6), comprises 36 genera, embracing 278 species. Only 14 genera and 44 species are found along the eastern coast of North America. Some of these genera do not have comb plates, or have them in very rudimentary form, as in *Ophiomusium*.

After eliminating the forms of this family that lack pronounced comb plates, there remain about 25 species, grouped under the following genera: *Amphiophiura*, *Stegophiura*, *Ophiura*, *Ophiocten*, *Homalophiura*, and *Ophiothyreus*. The ventral arm plates of the genera *Ophiura*, *Ophiocten*, *Homalophiura*, and *Ophiothyreus* are wider than those of the fossil form and are not very long. The ventral arm plates of *Stegophiura* are too small to be related to the fossil form. The radial shields of *Homalophiura*, *Ophiothyreus*, and *Stegophiura* are decidedly unlike those of the Oligocene species, and their dorsal arm plates are larger and more conspicuous. On the dorsal side of the disk of *Ophiocten* the disk plates are not entirely exposed, being covered by minute spines or granules. This leaves only the genus *Amphiophiura* to which a relationship can be shown. Six species of *Amphiophiura* now live off the east coast of North America, none of which are identical in all respects with the fossil form. The new Oligocene species is tentatively referred to the genus *Amphiophiura* and is given the specific name *oligocenica*.

## Class OPHIUROIDEA

## Order CHILOPHIURIDA Matsumoto

## Family OPHIOLEPIDIDAE Ljungman

## Subfamily OPHIOMASTINAE Matsumoto

### Genus AMPHIOPHIURA Matsumoto

The genus *Amphiophiura* was proposed by Matsumoto (7) in 1915 and characterized as follows:

> Disk high, often convex, covered with plates and scales, among which the primaries are very prominent. Radial shields stout, joined in pairs. Arm, combs, and genital papillae present. Oral shields oval, pyriform or trefoil. Second oral tentacle pores open, more or less, or entirely, outside oral slits; large, guarded by numerous scales. Arms moderately long, gradually tapering outwards, with blunt tips. Dorsal and ventral arm plates fairly well developed; successive plates in contact with each other at least on proximal arm joints. Lateral arm plates high, with few to numerous short, peg-like arm spines. Tentacle pores large, with numerous scales.

#### AMPHIOPHIURA OLIGOCENICA C. Berry, n. sp. Figures 1–23

Disk plate: Outline pentagonal, external surface (fig. 10) smooth but concave; outline indicates that it is probably the central disk plate; no evidence that other plates overlapped it. Inside surface (fig. 12) smooth but roundly arched so that center of plate is thickest. Diameter, 0.57 mm.

Radial shield: Outline spatulate, broader portion aboral; external surface (fig. 15) smooth, slightly swollen, showing no evidence of having been overlapped by other plates; internal surface

(fig. 18) smooth, slight curvature transverse to long axis of plate; raised area in corner of lateral and aboral margins acting as condyle. Length 0.77 mm. width 0.59 mm.

Comb plate: Outline a modified triangle; external surface (fig. 2) convex; aboral margin rounded and thicker than adoral margin; no evidence of comb papillae on aboral margin; inside surface (fig. 4) concave in general, with raised area crossing plate from dorsal to ventral portion; along dorsal margin is a flat irregularly outlined area of articulation. Length 0.80 mm., width 0.44 mm. at maximum.

Side mouth shield: Plate in general trowel-shaped; outline triangular with high thin apophysis at aboral end on internal surface; outside margin unevenly broken; inside margin straight; adoral end sharply pointed; aboral margin rendered irregular by apophysis. Ventral surface (fig. 9) swollen parallel to axis of plate; slight groove near aboral inside corner. Internal surface (fig. 13) uneven, raised area along central axis ending in high, pointed, straight-sided apophysis near aboral inside corner; inside margin of apophysis vertical, outside slanting; shallow groove paralleling outside of plate. Plate 0.77 mm. radially, 0.39 mm. tangentially, and 0.31 mm. from tip of apophysis to external surface of plate.

Ventral arm plate: First specimen. Outline a modified triangle with rounded corners, adoral apex blunt; lateral margins bisinuate, aboral margin strongly convex; external surface (fig. 3) smooth, slightly arched parallel to long axis; internal surface (fig. 21) concave, complying to external; lateral margins steep, giving illusion of ridge paralleling them; aboral portion sloping aborally to thin edge. Width and length of plate equal—length, 0.54 mm., width at aboral margin 0.54 mm.

Second specimen. Outline a truncated triangle, line of truncation forming adoral margin; aboral margin convex with rounded point situated in center; lateral margins bisinuate; external surface (fig. 19) smooth, slightly arched, parallel to long axis; internal surface (fig. 23) concave; lateral margins steep, pronounced at sinuses; aboral portion of plate sloping aborally to thin aboral edge. Proportion of width to length of plate about 1 to 2—length 0.82 mm., width at aboral margin 0.59 mm. The exact position of these two plates is uncertain.

Lateral arm plate: Right plate, is apparently abraded, as its edges are not sharp. Outline a modified rectangle whose sides are about equal in length; dorsal and ventral margins straight, converging slightly aborally; aboral margin convex; adoral margin concave; external surface (fig. 11) smooth, arched adoral—aborally; internal surface (fig. 14) irregular, in general concave with a low ridge crossing plate diagonally from dorsal-adoral corner toward ventral-aboral corner, adoral and aboral margins cumulating in this elevated ridge; narrow flat section along ventral margin. Height 0.54 mm.; width in middle, 0.51 mm.

Jaw: Only the adoral portion of this plate is present, being separated from the other part by the suture, which runs vertically across the jaw. Outline semi-rectangular (fig. 22); adoral margin straight; aboral margin has shallow sinus near ventral corner; ventral margin slants a little aboral-dorsally; dorsal margin has deep U-shaped sinus near aboral end, which is rounded; this sinus is for the circumoesophageal nerve-ring; surface smooth, slightly depressed in center portion, and rounding down to form the aboral and ventral margins; other side (fig. 20) differs in having the surface raised along the ventral margin. Height across adoral end 0.62 mm.; length along ventral margin 0.41 mm.

Genital plate: Only aboral two-thirds of left plate present. Outline irregular, in general stylate; large process forms aboral portion; inside lateral margin near aboral end swollen, outside lateral margin straight, adoral end broken diagonally across; dorsal surface (fig. 1) smooth, arched parallel to axis of plate, surface of process slightly roughened; ventral sur-

face (fig. 5) slightly arched, uneven, surface of aboral outside corner of process sloping towards dorsal surface, showing ventral surface of dorsal portion of process. Length 0.87 mm.; width at aboral end 0.60 mm.

Vertebral ossicle: Adoral view (fig. 17). Surface uneven, outline rectangular, upper and lower canal furrows indenting the surface for variable distances; surface of ala uneven, cumulating into centrally located zygapophysis whose outline is somewhat cordate; ventral of zygapophysis and a little to lateral side of it are two sharp-pointed condyles, between them a deep semicircular depression; adoral side of posterior hypapophyses occupies ventral-lateral corners.

Aboral view (fig. 16). Outline same as in reverse view, surface very uneven, central portion greatly raised, consisting of steep-sided zygosphene dorsal or lower canal furrow, two paired zygocondyles dorsally of zygosphene, and the wing-like anterior hypapophyses which bound the lower canal furrow on its lateral sides; surface of parapophyses concave, sloping adorally to lateral margin of plate; upper alar ridge partly exposed above dorsal edge of parapophyses; zygosphene longer than wide, proportions about 2 to 1; zygocondyles smaller.

Lateral view (fig. 7). Outline irregular, surface uneven, larger portion made up of concave parapophyses, dorsal margin even except for upper alar ridge at adoral corner, adoral margin uneven, consisting of zygapophysis in dorsal portion and sharp condyle in ventral portion; ventral surface uneven, showing both posterior and anterior hypapophyses; aboral margin uneven, showing zygosphene in ventral portion and zygocondyle in central portion.

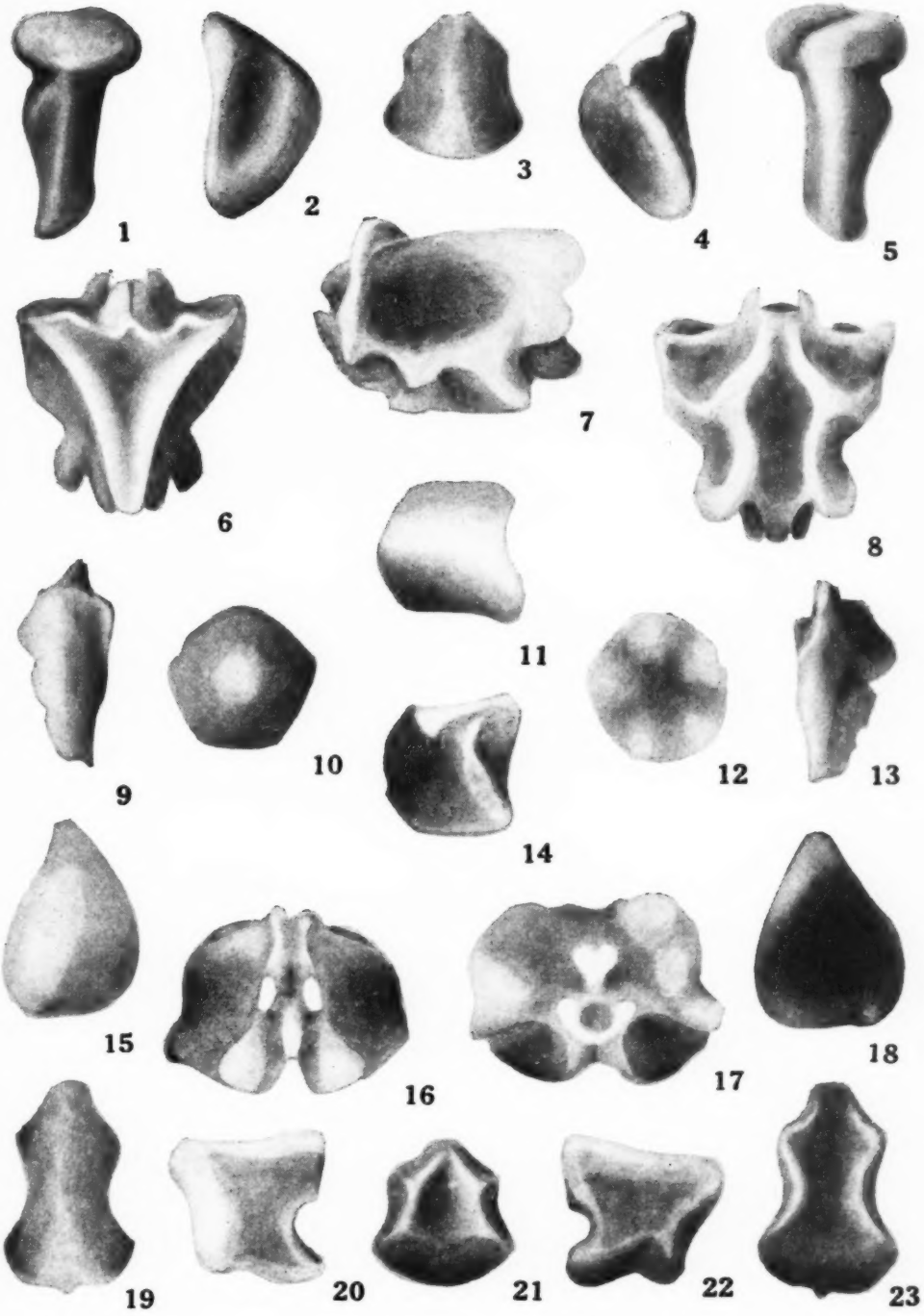
Dorsal view (fig. 6). Surface very uneven, outline a modified equilateral triangle, the base of which is situated adorally; dorsal edges of the parapophyses unite aborally in an acute angle with a rounded point; adorally they unite with the ala in the adoral-lateral corners; dorsal surface of parapophyses slopes ventrally towards longitudinal axis of plate and form a deep V-shaped area, the upper canal furrow; diagonal view of adoral side shows centrally located zygapophysis flanked by two sharp condyles and portion of the ala; sigmoid upper alar ridge divides the adoral side from the dorsal side; two rounded lobes, one on each lateral side of ossicle in aboral portion, are anterior hypapophyses; aboral end consists of rounded end of union of dorsal edges of parapophyses, which is the extension of the zygosphene, flanked by two zygocondyles.

Ventral view (fig. 8). Surface very uneven, outline same as in dorsal view; logitudinally across surface is deep, vertical-sided lower canal furrow flanked by high narrow ridges; posterior hypapophysis divides the lateral portions into adoral and aboral parts; ventral side of anterior hypapophysis situated in aboral portion; centrally located rounded zygosphene flanked by two rounded zygocondyles makes up aboral end; in center of adoral margin is rounded zygapophysis and two small sharp condyles.

Greatest length of the vertebral ossicle is 0.93 mm., width 0.87 mm., height 0.69 mm.

*Discussion.*—Dorsal arm plates, oral shield, and interradial marginal plates were not found. Whether the lack of these plates is due to their absence in the species or to accident in preservation is unknown. The interradial marginal

FIGS. *1–23*—*Amphiophiura oligocenica* C. Berry, n. sp., syntypes, ×37. *1*, Genital plate, left, dorsal view; *5*, ventral view. *2*, Comb plate, outside view; *4*, inside view. *3*, Ventral arm plate, ventral view; *21*, dorsal view. *6*, Vertebral ossicle, dorsal view; *7*, lateral view; *8*, ventral view; *16*, aboral view; *17*, adoral view. *9*, Side mouth shield, ventral view; *13*, dorsal view. *10*, Central disk plate, dorsal view; *12*, ventral view. *11*, Lateral arm plate, outside view; *14*, inside view. *15*, Radial shield, dorsal view; *18*, ventral view. *19*, Ventral arm plate, ventral view; *23*, dorsal view. *20*, *22*, Jaw. (p. 236)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plates are not distinctive in all Ophiolepididae. From the number of ventral arm plates it is to be expected that the dorsal arm plates would be present, but in the living genus *Aspidophiura* the dorsal arm plates are absent (8), and in the genus *Ophiomusium* the ventral arm plates appear on only the first two or three segments of the arm. However, the dorsal arm plates are present, even though in rudimentary form, in many species. In *Amphiophiura oligoceneca* the number of ventral arm plates found indicates that they were not limited to the first two or three segments. The dorsal sides of the lateral arm plates do not show any evidence that they were in contact with each other on a straight line, as is usual when there are no dorsal arm plates. The lack of the oral shield can be explained by breakage during preservation or washing.

Of the six species of *Amphiophiura* living along the Atlantic coast of North America, *A. metabula* shows the closest similarity to *A. oligocenica;* the points of similarity between these two forms are the ventral arm plates, the radial shields, the side mouth shields, and the general size of the animal. There are other points of similarity between the fossil form and other species of the genus. The similarities, however, do not justify the reference of the fossil to any of the living species.

REFERENCES

1. Conrad, T. A., *Acad. Nat. Sci. Philadelphia, Jour.*, 2d ser., vol. 1, pp. 111–134, 1848.
2. Cooke, C. W., and Cushman, J. A., *U. S. Geol. Survey, Prof. Paper* 129, p. 79, 1922.
3. ——, ——, *op. cit.*, p. 81.
4. ——, ——, *op. cit.*, p. 88.
5. Clark, H. L., *Harvard Univ., Mus. Comp. Zoology, Mem.*, vol. 25, no. 4, pp. 310–315, 1915.
6. ——, *op. cit.*, pp. 307–345.
7. Matsumoto, H., *Nat. Acad. Sci. Philadelphia, Proc.*, vol. 67, p. 77, 1915.
8. Mortensen, Th., *Handbook of the Echinoderms of the British Isles*, Oxford Univ. Press., p. 299, 1927.

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JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 3, PP. 241–247, 6 TEXT-FIGS., APRIL, 1937

# A PRELIMINARY REVIEW OF CERTAIN FAMILIES OF DIPTERA FROM THE FLORISSANT MIOCENE BEDS

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ABSTRACT

The dipterous families Bibionidae, Stratiomyidae, and Empididae of the Florissant (Miocene) shales are reviewed, and keys are given to all the known species. One new genus and five new species, three of these representing genera new to the Florissant shales, are described. The generic position of three species is discussed, and two new combinations are proposed. The venation of all new species is shown, in part or entirely, by line drawings.

A study of certain Diptera from the Miocene shales of Florissant has revealed new species represented by specimens which are well enough preserved to justify description. It is the purpose of this paper to describe these, and to give, as nearly as possible at the present time, a review of the families Bibionidae, Stratiomyidae, and Empididae as they occur in these deposits. To this end, a study has been made of the Cockerell types in the University of Colorado Museum, to which the curator, Mr. H. G. Rodeck, has kindly given me access. I am also indebted to Dr. F. M. Carpenter and the Museum of Comparative Zoology for the loan of much good material. Types of the species described herein are, unless otherwise stated, the property of the University of Colorado Museum.

## Family BIBIONIDAE

The Bibionidae are very numerous in the Florissant shales, and are among the most characteristic fossils of these deposits. The following key will aid in distinguishing the known Florissant Miocene species. The *Plecia* section is taken from Cockerell (U. S. Nat. Mus., Proc., vol. 53, p. 391, 1917).

1. Radial sector branched; anterior tibiae simple (*Plecia*) . . . . . 2
   Radial sector simple; anterior tibiae terminating in a strong outer spur and a shorter inner one . . . . . 5
2. Small; wing 6 mm. long . . . . . *Plecia melanderi* Ckll.
   Larger; wing 8 mm. or over . . . . . 3
3. Wing long and narrow; marginal cell narrow, its greatest depth less than 400$\mu$ . . . . . *Plecia explanata* Ckll.
   Wing ordinary; marginal cell broader, its greatest depth over 450$\mu$ . . . . . 4
4. Abdomen with the light bands wider than than the dark bands; submarginal cell broader . . . . . *Plecia axeliana* Ckll.
   Abdomen with the dark bands much wider than the light; submarginal cell narrower . . . . . *Plecia decapitata* Ckll.
5. Radius fused for a short distance with the media, the cross vein *r-m* being eliminated; posterior veins indistinguishable from the membrane; femora not clavate . . . . . *Bibiodes intermedia* James
   Radius free from the media for its entire length (*Bibio*) . . . . . 6
6. Posterior veins indistinguishable from the membrane; posterior femora more or less clavate; length, 8 mm. or less . . . . . 7
   Posterior veins conspicuous, though weaker than the anterior ones; posterior femora not clavate; length, 10 mm. or more . . . . . 8
7. Red and black species; base of radial sector much longer than cross-vein *r-m;* hind femora thickest before the apex . . . . . *Bibio cockerelli* James

Reddish species; base of radial sector but slightly longer than cross-vein *r-m;* hind femora strongly clavate, thickest at the apex, the tibiae also clavate. . . . . *Bibio vetus* James

8. Black species; base of radial sector much shorter than cross-vein *r-m*. . . . . *Bibio atavus* Ckll.

Black and brown species; base of radial sector much longer than cross-vein *r-m* . . . . . *Bibio wickhami* Ckll.

### Genus Plecia Wiedemann, 1828

This genus, represented by at least four Florissant species, as compared with one in Colorado, was much more abundant in the Miocene. Most Holocene species belong to the tropical regions. The Florissant species are well described by Doctor Cockerell, and I can add nothing. My material in this genus, however, has been scant so far as well-preserved specimens are concerned.

### Genus Bibio Geoffroy, 1862

#### Bibio atavus Cockerell

*Bibio atavus* Cockerell, *1909*, Entomologist, vol. 42, p. 173, 1909.

Aside from the type, I have not seen this species among the materials which I have had for study. It is unique, both among the Miocene species of Florissant and the recent species known to me, for the great length of the cross-vein *r-m*, which character it shares, however, with the Oligocene *B. gurnetensis* Ckll. of England; this character, together with the large size, the dusky wings (darker along the costal margin), and the comparatively strong venation of the posterior half of the wings, makes the species easy to identify if good specimens are to be had.

#### Bibio wickhami Cockerell

*Bibio wickhami* Cockerell, *1914*, Acad. Nat. Sci. Philadelphia, Proc., p. 647; *1917*, U. S. Nat. Mus., Proc., vol. 52, p. 374.

By far the most abundant *Bibio* in the Florissant shales, just as the closely related *B. albipennis* is the most abundant species in the Rocky Mountains today. Characterized by the large size (11 mm. or more), the very short cross-vein *r-m*, and the contrasting black thorax and brownish abdomen. The posterior veins are distinct in well-preserved specimens, though not so dark as the anterior ones. The inner spur of the anterior tibiae is about half the length of the outer one.

#### Bibio cockerelli James, n. sp.

Figure 1

Length, 7 mm.; of wing 5 mm. Apparently a male. Eyes brown, clothed with long but rather sparse black pile; proboscis and face brown. Thorax black, with short but rather dense black pile dorsally; the pleura brownish; legs, except possibly coxae, brown, the hind femora, however, mostly black; the anterior and middle legs short; hind legs rather long, the femora and tibiae each almost the combined length of the middle femora and tibiae; hind femora moderately clavate, the greatest enlargement being at about two-thirds their length; hind tibiae also clavate, the greatest enlargement being apical; hind basitarsi twice as long as the following segment, not enlarged. Wings hyaline; the veins along the costal margin reddish, the others clear hyaline, distinguished only with difficulty; cross-vein *r-m* very short, 0.03 mm. in the type, compared with 0.36 mm. for the basal part of the radius sector; stigma pale. Abdomen bright-red, brownish at the sutures and laterally.

Types: Holotype and reverse of type, Miocene shales of Florissant, Station 17 (T. D. A. Cockerell)

*Discussion.*—Several additional specimens are not well enough preserved to be given a type designation. This species resembles *Bibiodes intermedia*, but is a true *Bibio*. Among Recent species, it is closest to those of the *longipes* group, but differs in the shortness of the cross-vein. The combination of this character with the weakness of the posterior veins is one unknown to me among Recent species of *Bibio*.

BIBIO VETUS James, n. sp.

Figure 3

Male. Length 8 mm. An apparently bare, wholly yellow or pale-brown species, the thorax slightly darker than the remainder of the body. Eyes without evident hair, yellow; ocellar triangle and proboscis light brown. Anterior and middle femora short and thick, the anterior femora half, the middle ones one-third, as thick as long; anterior tibiae short and thick, with a long outer spur and a much shorter inner one; the right anterior tarsus seems abnormally elongated; hind femora and tibiae strongly clavate, both segments thickest near the apex; hind femora as long as the front femora and tibiae combined; hind basitarsi definitely enlarged (but only one-half the thickness of the apices of the tibiae) and elongated, being as long as the combined length of the two following segments; length of hind tarsi 1.6 mm., of basitarsi, 0.6 mm. Wing clear hyaline; the anterior veins yellow, the posterior ones concolorous with the membrane, almost indistinguishable; cross-vein *r-m* almost as long as the stem of *Rs*. Abdomen unicolorous.

Measurements, in microns: length of hind femur, 2250, maximum width, 500; length of hind tibia, 2200, maximum width, 400.

Types: Holotype and reverse of type, male, Miocene shales of Florissant, Station 14 (W. P. Cockerell).

*Discussion.*—This species is very close to such Recent species as *Bibio longipes* Loew and *Bibio pingreensis* James, both of which inhabit the Rocky Mountain region today. The insect was probably lightly clothed with pale pile, although I can not detect any under the low power of the compound microscope.

Genus BIBIODES Coquillett, 1904

BIBIODES INTERMEDIA James, n. sp.

Figure 2

Length, 6.5 mm. (male), 7 mm. (female); of wings, 4 mm. Eyes brown, hairy, conspicuously so in the male, less so in the female; face of female pale reddish; antennae not evident; proboscis apparently brown. Thorax black; clothed with rather long, black, hair, in moderate abundance; the pronotum of the female apparently brownish; legs black; the middle and hind legs of the female brownish, but not strongly contrasting; the middle and hind tibiae and tarsi of the male reddish, in contrast to the black femora; pile abundant, short, concolorous with segments; anterior tibiae short and stout ending in the usual stout spur, their basitarsi long, as is normal; the middle and hind femora stout, each about equal in length to its tibia, but twice as thick; none of the femora or tibiae clavate; the middle femora and tibiae each almost as long as, the hind femora and tibiae each slightly longer than, the combined lengths of the anterior tibiae and basitarsi; hind basitarsi twice as long as the second tarsal segment, definitely thickened in the male. Wings hyaline, stigma apparently wanting; veins pale red, the anterior ones thickened as in Recent *Bibiodes*, the others obscure; subcosta obsolete; the anterior section of the radial sector of ordinary length, but longer than the region of coalescence with the media, that part being unusually short; the free apical part of the radial sector bows strongly toward $R_1$ and ends near the wing apex, about as in the recent *B. halteralis;* also as in this species, the costa forms a stump beyond the apex of the radius. Abdomen red, abundantly clothed with reddish pile; the sutures paler; genitalia black.

Measurements, in microns: basal part of the radial sector, 200; part of radial sector fused with media, 130; radial sector from separation of media to apex, (distance in a straight line), 1870; height of axillary cell at origin of radial sector, 160; height of first basal cell at origin of radial sector, 160.

Types: Holotype, male, allotype, female, Miocene shales of Florissant, Sta-

tion 13; paratypes, female, Station 13B; (W. P. Cockerell) and female, Station 17 (M. T. James).

*Discussion.*—In two other females, probably conspecific with the above, well-preserved pale brown antennae; the basal two segments together are approximately half as long as the flagellum.

This species is quite similar to the recent *B. halteralis* Coq., but is much

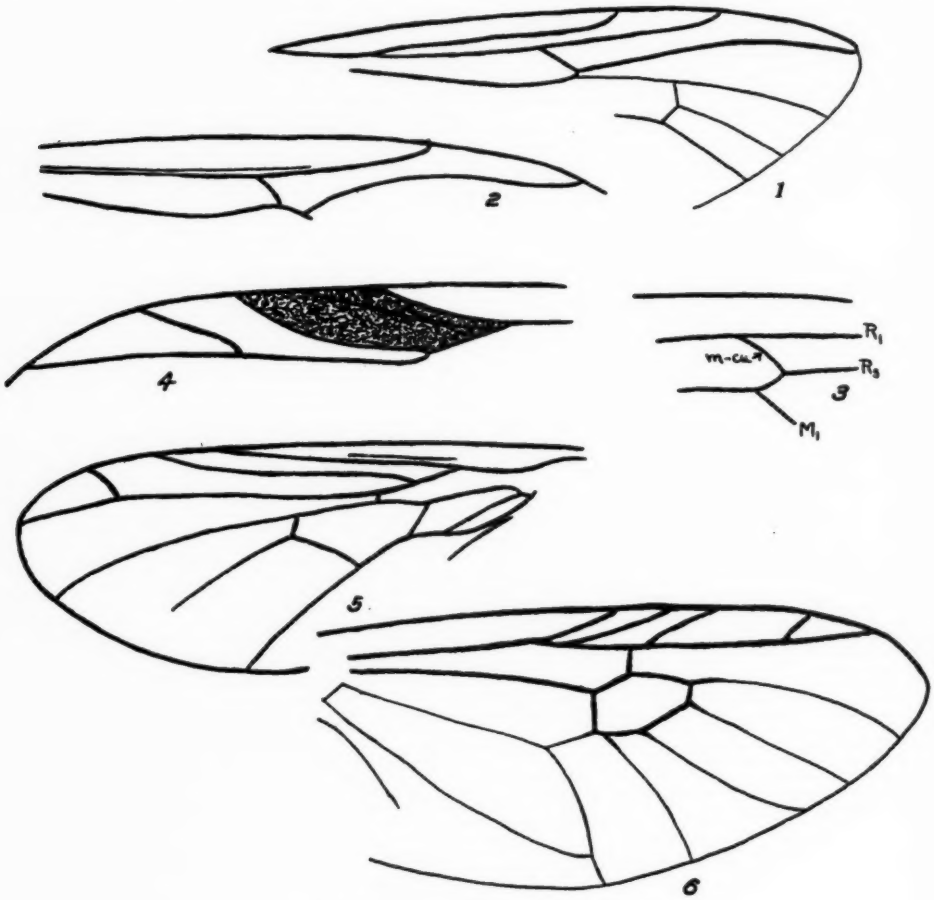


FIG. 1—*Bibio cockerelli* James, n. sp.
2—*Bibiodes intermedia* James, n. ps.
3—*Bibio vetus* James, n. sp.
4—*Beris miocenica* James, n. sp.
5—*Progloma rohweri* James, n. sp.
6—*Lasiopa carpenteri* James, n. sp.

(4940, Station 13, W. P. Cockerell, and 4920x), the pleura are extensively brown, in contrast with the black mesonotum, the legs are entirely brown, and the length is 7.5 to 8 mm. One of these has larger; the greater size, together with the short extent of the coalescence of the radius and media, seems to indicate that it is much closer to the common *Bibio-Bibiodes* stem than are our recent species.

The amount of sexual dimorphism, also, is greater than is found in Recent species, but it is quite within the range for *Bibio*. The specific name is intended to indicate that this species shows affinities with *Bibio*. There is no doubt in my mind but that the male and females included above are conspecific.

## Family STRATIOMYIDAE

Only five species have been recognized from the Florissant Miocene: these may be tabulated as follows.

1. Abdomen eight-segmented; vein $R_4$ almost half as long as vein $R_5$ . . . . . *Beris miocenica* James
   Abdomen five- or six-segmented; vein $R_4$ much less than half as long as vein $R_5$ . . . . . 2
2. Cross-vein *m-cu* present, though short; discal cell 2.5 times as long as wide . . . . . *Cyphomyia rohweri* (Ckll.)
   Cross-vein *m-cu* absent; discal cell less than twice as long as wide . . . . . 3
3. Face conically produced; union of fifth posterior with discal cell punctate . . . . . *Rhingiopsis(?) prisculus* (Ckll.)
   Face not conically produced . . . . . 4
4. Discal cell on fifth posterior, 384 microns, on fourth, 320, on third 256 . . . . . *Oxycera contusa* Ckll.
   Discal cell on fifth posterior 110 microns, on fourth 415, on third 610 . . . . . *Lasiopa carpenteri* James

### Genus BERIS Latreille, 1804

#### BERIS MIOCENICA James, n. sp.

Figure 4

Length, 8.5 mm.; of abdomen, 4.5 mm.; of wing, 5 mm.; of head, 1 mm. A black species, with reddish legs and a reddish-brown abdomen. Antennae black, the third segment inflated, its width half its length. Pile of body short but moderately abundant; that of abdomen black, that of thorax reddish, most abundant near the incisures. Abdomen extending slightly beyond the wing tips. Wings dusky, the stigma brown; veins evident, brown. Second submarginal cell blunt at the base.

Measurements, in microns; $R_s$, origin to apex, 2667; $R_s$ to origin of $R_{2+3}$, 390; length of $R_5$, 1222; length of $R_4$, 580; length of antennae, 600.

Type: Holotype, female, Miocene shales of Florissant, Station 17B (W. P. Cockerell).

*Discussion.*—The dorsal part of the insect is exposed; the wings are folded over the abdomen, so that only the costal region, including the subcosta and the radius, with its branches, is visible. Scutellar spines can not be distinguished. However, I have little hesitation about referring this specimen to *Beris*. The general appearance of the fly suggests that genus; the antennae and scutellum, as far as the latter is visible, are right; the abdomen is eight-segmented; and the venation, as far as visible, is almost identical with that of *B. chalybeata* Forst. (specimens from England, several localities, and from Tervueren, Belgium). I feel, therefore, that this specimen is worthy of description and that the generic reference may be made with fair certainty.

### Genus CYPHOMYIA Wiedemann, 1825

#### CYPHOMYIA ROHWERI (Cockerell)

*Oxycera rohweri* COCKERELL, *1916*, U. S. Nat. Mus., Proc., vol. 51, p. 90.

This is certainly not an *Oxycera;* the presence of the cross-vein *m-cu* (even though very short), the great length and shape of the discal cell, the strength of the veins emerging from the discal cell, and the details of the venation of the anterior part of the wing exclude it from that genus. Unfortunately, the antennae are not preserved in the type. However, I have no hesitation in referring this species to *Cyphomyia* or to a very close (and perhaps extinct) genus (cf. figure of *Neorondania chalybea* in Curran's *Manual*, p. 138, fig. 40). The venation in *Cyphomyia* is, within certain limits, subject to variation, and an undertermined species in my possession approaches very

closely the venation of *rohweri*. The two-spined scutellum, the broad, flat abdomen, and other visible features are compatible with this generic disposition.

My interpretation of the venation differs in one respect from that of Professor Cockerell. His figure shows the veins forming the lower side of the discal cell as continuous in a straight line. According to my interpretation, they meet, at the origin of the third posterior vein ($M_3$) to form an angle somewhat less than a straight angle (perhaps about 150°); the line therefore is bent, so that the discal cell bulges outward at this point. The portion of vein $M_2$ at the apex of the discal cell also appears shorter than in Professor Cockerell's figure, being no longer than cross-vein *r-m*.

The shortness of the cross-vein *m-cu* in this species probably has a considerable phylogenetic significance. The Stratiomyinae, which are supposed to have this cross-vein, and the Clitellariinae, which supposedly lack it, are by most workers considered only doubtfully distinct. This species is probably one of the connectant forms between these two subfamilies and may indicate a connection between *Cyphomyia*, a primitive Stratiomyine, and the ancestor of the *Clitellaria-Adoxomyia* complex.

## Genus RHINGIOPSIS Roder, 1886

### RHINGIOPSIS? PRISCULUS (Cockerell)

*Nemotelus prisculus* COCKERELL, *1910*, Am. Mus. Nat. Hist., Bull., vol. 28, p. 286.

This can not be *Nemotelus;* the venation is of an entirely different type. The *Nemotelus*-like face is compatible with *Rhingiopsis*, and the venation is of a similar type, except for the punctate cross-vein *m-cu*. It is possibly ancestral to our modern species of *Rhingiopsis*. Professor Cockerell suggests that this species should, perhaps, deserve a separate generic name; but not having seen the type, I do not feel in a position to suggest one.

## Genus OXYCERA Meigen, 1803

### OXYCERA CONTUSA Cockerell

*Oxycera contusa* COCKERELL, *1917*, Biol. Soc. Washington, Proc., vol. 30, p. 20.

I have not seen the type, and have not recognized this species from other material from Florissant. However, Professor Cockerell's description would indicate that it is a true *Oxycera*. This is rather surprising, in that *Oxycera* seems to be a rather advanced type, derived from the *Euparyphus* stem; on the other hand, the comparatively large number of species and broad distribution of *Oxycera* would indicate a fairly early origin for the genus.

### LASIOPA CARPENTERI James, n. sp.

Figure 6

Male: A black species, apparently unmarked; the femora are brownish on the apical half, the genitalia brown to yellow, and the anterior and posterior tibiae yellow (the middle ones missing); the proboscis, antennae, and all visible pile are black.

Antennae short, the first and second segments of about equal length, the first somewhat longer than broad, the second definitely broader than long, broadest at the apex; the third segment broader than the second, its first three annuli (all that are visible) together about twice the length of the second segment. Face pilose below the antennae, slightly narrower than the diameter of the eyes; eyes bare, contiguous above, the facets of equal size above and below; proboscis short. Thorax short-pilose dorsally, with rather long pile on the pleura. Scutellum rounded, apparently without spines. Abdomen with considerable short pile particularly on segments four and five, and on the terminal genital segments; venter without evident pile. Wings pale yellow, the veins brown; cross-vein *r-m* erect; posterior veins evident to the wing margin; vein $M_3$ converging apically toward $M_2$; the union of the discal and fifth posterior cells short; the base of the

fourth posterior much shorter than that of the third posterior cell. Length, excluding antennae and genitalia, 10.5 mm.; of head, 2 mm.; of thorax, 4 mm., of abdomen, 4.5 mm., of genitalia 1 mm., of wings, 8 mm., width of head, 2 mm., of thorax, 4 mm.; of abdomen, 4.5 mm., of wing, 3 mm. The following measurements are in microns. Base of second posterior cell, 220, of third, 610, of fourth, 415; union of discal and fourth posterior cells, 110; length of *r-m*, 300; length of discal cell, 1150, width, 640.

Types: Holotype and reverse of type, Miocene shales of Florissant. In the Museum of Comparative Zoology.

## Family EMPIDIDAE

*Key to species*

1. Third vein furcate.....3
   Third vein not furcate (*Rhamphomyia*)...2
2. Praefurca gently bowed; abdomen much paler than the thorax.....
   .....*Rhamphomyia sepulta* Ckll.
   Praefurca strongly bowed; abdomen almost as dark as thorax.....
   .....*Rhamphomyia hypolitha* Ckll.
3. Body robust; abdomen as broad as long.
   .....*Progloma rohweri* James
   Body slender; abdomen several times as long as broad (*Empis*).....4
4. Length over 7 mm.....*Empis perdita* Ckll.
   Less than 6 mm.....5
5. A robust species, 5.5 mm. in length; veins $R_{2+3}$ and $R_{4+5}$ subequal in length.....
   .....*Empis miocenica* Ckll.
   A less robust species, 4.5 mm. in length; vein $R_{4+5}$ about twice the length of $R_{2+3}$
   .....*Empis florissantana* Ckll.

### Genus PROGLOMA James, n. gen.

This genus is proposed for an *Empis*-like species with a short proboscis and a broad, robust body. In general aspect it resembles the South American *Phleboctena*, though the wing venation shows closer affinities with *Gloma* and *Empis*. Indeed, the wing might pass for that of the latter genus. The venation differs from that of *Gloma* in the following respects: the furcation of $R_{4+5}$ is beyond the apex of $R_{2+3}$; the discal cell is shorter in proportion to $M_1$; and the lower margin of the discal cell is shorter (cf. text figure of *Progloma*, and Curran's figure of *Gloma*, in the *Manual*, p. 210, fig. 34). The body also is more robust than in *Gloma*.

Type: *Progloma rohweri*, new species.

PROGLOMA ROHWERI James, n. sp.

Figure 5

Length, 5 mm., of wings, 5 mm. Head black, with stiff black pile; eyes brown; eyes separated by a distance equal to about half their width; proboscis black, short, length, about 0.40 mm. Thorax black, black-haired; scutellum broad, fringed with black pile and several black bristles. Abdomen as long as wide, rounded in profile, with five segments evident, brown, with abundant short brown pile and rows of black, bristle-like hairs near the apices of the segments. Legs brown with brown pile; wings hyaline, the veins yellow.

The following measurements are in microns. Greatest length of discal cell, 1000, greatest width, 450; vein $M_1$ from discal cell to wing apex, 2000; length of vein $R_4$, 400; length of $R_5$, 800, of $R_{4+5}$ from origin to furcation, 2300; greatest length of second basal cell, 1000; length of head, 680, of thorax, 2100, of abdomen, 2000; width of head, 760, of thorax, 1600; of abdomen, 2000.

Types: Holotype and reverse of type, apparently a female, Miocene shales of Florissant, Station 13 (S. A. Rohwer).

NOTE: The manuscript of this paper was received by the editor February 5, 1937.

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# A NEW EOCENE SEA-URCHIN FROM ALABAMA

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ABSTRACT

*Porpitella micra* represents a genus of echinoids not hitherto known in America.

A series of very small sea-urchins sent to the Alabama Geological Survey by Mr. George J. Rice and later sent to me by Miss Winnie McGlamery, of the Survey, prove of unusual interest as they seem to represent a genus not hitherto recorded from America. They are obviously closely related to *Echinocyamus*, but differ from that genus in having a supramarginal periproct. They appear to be congeneric with those small Scutellinas for which Pomel (1883, Classification Méthodique et Genera des Échinides, vivant et fossiles, p. 72) established the genus *Porpitella*. Lambert and Thiéry (1914, Essai de Nomenclature Raisonné des Echinides, fasc. IV, p. 294) definitely designated the type as *Cassidulus hayesiana* Desmoulins, which they, like Cotteau (1891, Paleontologie Française, Terrain Éocène, Vol. II, p. 339), consider synonymous with *Scutellina supera* Agassiz. A specimen of this species from Agassiz's own collection is at hand for comparison with the Alabama material. It is much larger than any of the latter series, measuring 17 by 15 mm., and the longitudinal concavity of the lower surface is much more marked. But the essential characters are surprisingly similar and warrant the use of the name *Porpitella* for the Alabama form, the description of which is as follows:

PORPITELLA MICRA H. L. Clark, n. sp.
Text-figures 1–3

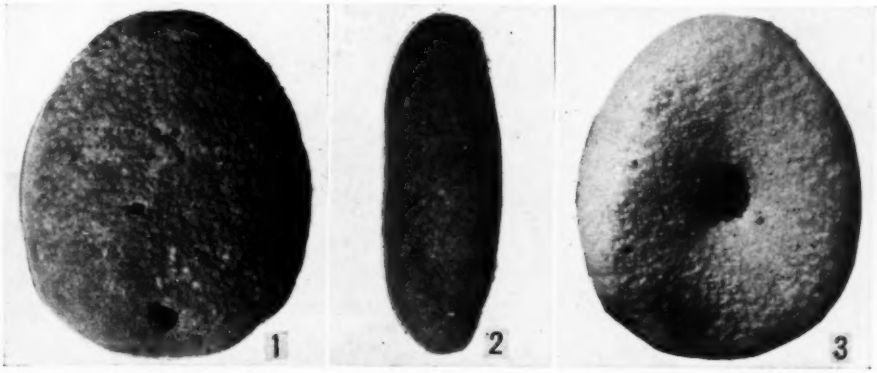
Length, 8 mm.; breadth, near middle and posteriorly, 6.5 mm., but 2 mm. from the anterior margin it is only 5 mm.; height rather more than 2 mm. Test flattened aborally, longitudinally concave orally, uniformly but not very closely covered with rather small tubercles, each of which is surrounded by a deeply sunken scrobicule. Apical system distinctly in front of middle; anterior pair of the 4 genital pores just 3 mm. from test margin; posterior pair of pores more widely separated from each other than are the anterior pair; distance between the two pairs about equal to distance between pores 1 and 4. All the genital pores relatively very large; no ocular pores visible. Madreporic body damaged so that the number of pores cannot be determined but other specimens indicate at least 4.

Petals fairly distinct with straight diverging poriferous zones; petal III has only 8 or 9 pairs of pores on each side, but the other petals are somewhat longer and perhaps narrower with about 12 pairs; the pores themselves are about as big as the primary tubercles but much smaller than the scrobicules. Periproct supramarginal, about half a millimeter in diameter, more or less circular, some 0.75 mm. from posterior margin of test. Peristome central, more than a millimeter in diameter, its length a trifle greater than its width. Ambulacral furrows scarcely indicated. On the internal

surface of the test are 10 well developed vertical walls, bounding the ambulacra as in *Echinocyamus*, but they do not extend more than half way from the ambitus to the peristome.

Holotype: Alabama Mus. Nat. Hist. 85. From a "well, Oakley Estate #2, sec. 9, T. 3, R. 29, Houston County, Alabama; cuttings at 3800–4000 ft; associated with the echinoids in the cuttings are specimens of *Ostrea sellaeformis* Conrad."

There are 26 paratypes from the same locality which show great diversity in form and in the condition of preservation. Few are as well preserved as the holotype, and in most cases the petals cannot be distinguished. The smallest specimen is only 5 by 4 mm., with the outline of the test much as in the individual described. The largest specimen, 9.5 by 8.5 mm., is more than 3 mm. high with the abactinal system forming a distinct apex, and the anterior end much narrower than the posterior. Another high specimen, not quite 9 mm. long, is only 7 mm. wide posteriorly and less than 5 mm. wide, across the open end of petal III. Other specimens are much flatter; one, 9 mm. long and 7.5 mm. wide, is little more than 2 mm. high. While most individuals are distinctly longer than wide with the anterior end narrowed and the posterior margin nearly straight, some are almost circular, one noticeable example having the width 6 mm. and the length less than 7. In these more circular specimens the apical system is nearly central so that the anterior position so well shown in the holotype is not so constant a character as might be desired. Another feature in which much diversity is shown is in the concavity of the oral surface. In some cases, the concavity is marked and extends from the posterior margin nearly to the anterior end of the test; at the other extreme are individuals in which the whole oral surface is almost flat except for the depression surrounding the peristome.




FIGS. 1–3—*Porpitella micra* Clark, n. sp., holotype. Upper, lateral, lower surfaces of the test, ×6.

There is no American echinoid with which this little species will be confused, the supramarginal periproct and the character of the petals being sufficiently distinctive. From the European species *supera* (or *hayesiana*), the small size, relatively high test, short petals and usually anterior apical system separate it easily.

In regard to the stratigraphic position, Miss McGlamery writes: "the well from which these echinoids came seems to have been on a location in the Claiborne. Do you think it is likely that they are of Claiborne age?" As the European species of *Scutellina* and *Porpitella* are all of Eocene age, there is no apparent reason why these Alabama specimens should not have come from the Claiborne.

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## PALEONTOLOGICAL NOTES

# A FOSSIL EARTHWORM(?) FROM THE PALEOCENE OF WYOMING

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While engaged in collecting vertebrate fossils in the Paleocene sediments of northwestern Wyoming in the summer of 1935, the members of the Scott Fund Expedition of Princeton University found what appears to be a fossil terrestrial oligochaete—an earthworm. If actually the remains of an earthworm, this is the first fossil of such an animal ever discovered.

FIG. 1—Fossil earthworm (?) from Paleocene of Wyoming, $\times 3\frac{1}{3}$.

The object resembles the anterior third or quarter of the somewhat desiccated body of an earthworm. Closer examination suggests that it is actually the sand filling of a cavity formerly occupied by an earthworm, the tissues of which were removed by decomposition. Its length is 24 mm., greatest thickness 5 mm., greatest width 6 mm. is curved at an angle of about 45° 13 mm. from the anterior end, flattened dorsoventrally, and tapers to the anterior end both dorsoventrally and laterally. Sixteen segments can be seen, but some of them cannot be distinguished on the dorsal (convex) side. No other distinctive characters are visible. Whether setae or papillae were present cannot be determined because of the coating of sand particles which masks the surface.

This questionable fossil was collected on Polecat Bench, near Powell, Park County, Wyoming, from the base of the Paleocene Fort Union formation. The bed from which the fossil came is a stream deposit.

The specimen is no. 14198 in the paleontological collection of Princeton University.

While it cannot be proved that this object is actually a fossil earthworm, in size, shape, and general appearance it is remarkably similar to a modern terrestrial oligochaete. It seems probable that we have here a cast of part of the body of such an animal. It is hoped that additional and better-preserved specimens will be found in these beds in future years.

# SOME CHANGES IN NOMENCLATURE OF ARCHAEOCYATHI (CYATHOSPONGIA)

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In 1935, the author, examining young stages of Archaeocyathi, came to the conclusion that these organisms are closely related to sponges and should be included as a separate class in the phylum Porifera. The name Cyathospongia was proposed for the new class. Dr. R. S. Bassler very kindly pointed out that this name has been used for a genus of Silurian sponges. It seems necessary, therefore, that another name be substituted, and I suggest the name Pleospongia ("solid sponges," in reference to solid and not spicular skeleton).

It has also come to my attention, chiefly through the kindness of Dr. J. W. Wells, that certain generic names used for Pleospongia have been preoccupied. It is my intention in this paper to rectify these errors. In my opinion the nomenclature proposed by Walcott in 1886 is more nearly correct than that used by Hinde, Bornemann, Taylor, Vologdin, Bedford, and Okulitch, which was based on an incorrect interpretation as to which of Billing's species (1861) should be considered the genotype of *Archaeocyathus*. It is very unfortunate that this change has to be made now, after important works have been published, but the sooner the situation is cleared up, the better.

Billings in 1861 described two species of *Archaeocyathus* from Canada, *A. atlanticus* and *A. minganensis*. In 1865, he revised the original description and erected a new species, *A. profundus*. Realizing that *A. profundus* represents the characteristics of the genus better than does *A. atlanticus*, he considered *A. profundus* to be the genotype. According to the rules of nomenclature, however, the choice of the genotype is limited to the originally described species, that is, *A. atlanticus* and *A. minganensis*. Of these *A. atlanticus* was the first to be mentioned. Furthermore, *A. minganensis* was shown by Hinde to be not an archaeocyathid but a true sponge, and it was later given the name *Archaeoscyphia*. *Archaeocyathus atlanticus*, therefore, is the only permissible genotype for *Archaeocyathus*. Unfortunately, Hinde (1889) took the view that *A. profundus* is the type, and accordingly removed *A. atlanticus* to a new genus, *Spirocyathus*. The genus *Spirocyathus* was intended to include Pleospongia with curved parieties or a vesicular intermural tissue. In view of the foregoing, the name *Spirocyathus*, with its genotype *S. atlanticus*, is considered to be invalid, since it is an exact synonym of *Archaeocyathus;* and *A. atlanticus* is the genotype of the genus *Archaeocyathus*. The definition of the genus *Archaeocyathus*, based on *A. atlanticus* was given by Walcott in 1886.

*Archaeocyathus profundus* Billings, erroneously considered to be the type species, is distinct generically from both *Archaeocyathus* and the related genus *Ethmophyllum* Meek, 1868. It is, therefore, necessary to give *A. profundus* a distinct name. The new name *Cambrocyathus* is suggested for it and its congeners. This genus will include Pleospongia with straight radial parieties and simple walls. *Cambrocyathus profundus* (Billings) is the genotype. The generic and family definitions are given by Taylor for *Archaeocyathus* (1910).

Summarizing the above, the following changes in nomenclature are proposed: Spirocyathidae to be dropped as invalid; Archaeocyathidae to be used instead of Spirocyathidae (as used by Hinde, Bornemann, Taylor, Vologdin, Bedford, and Okulitch); *Cambrocyathus* Okulitch, n. gen., to include *Archaeocyathus profundus* and its congeners; Cambrocyathidae to be used instead of Archaeocyathidae (as used by Hinde, Bornemann, Taylor, Vologdin, Bedford, and Okulitch). The names *Heterocyathus* Bedford (Heterocyathidae) and *Rhabdocyathus* Von Toll (Rhabdocyathidae) are preoccupied—*Heterocyathus* by Milne-Edwards and Haime,

1848 and *Rhabdocyathus* by Brook, 1893. It is suggested that these names be replaced by *Radiocyathus* Okulitch, n. name, and *Rhabdocnema* Okulitch, n. name, respectively. The name *Acanthocyathus* Bedford should be written *Acanthinocyathus*, the error being a typographical one.

BIBLIOGRAPHY

BEDFORD, R. and W. R., *Kyancutta Mus., Mem.*, vol. 1, 1934; vol. 2, 1936.

BORNEMANN, J. G., Die Versteinerungen des cambrischen Schichtensystems der Insel Sardinien: *Kais. Leop.-Carol deutschen Akad. Naturfor. Nova Acta*, Band 51, Abt. 1, pp. 28–78, 1886.

HINDE, G. J., On Archaeocyathus Billings: *Geol. Soc. London, Quart. Jour.*, vol. 45, pp. 125–148, 1889.

MEEK, F. B., On a remarkable new genus of corals: *Am. Jour. Sci.*, 2d ser., vol. 45, pp. 62–64, 1868.

——, Note on *Ethmophyllum* and *Archeocyathus: Am. Jour. Sci.*, 2d ser., vol. 46, p. 144, 1868.

OKULITCH, V. J., Cyathospongia, A new class of porifera to include the Archaeocyathinae: *Roy. Soc. Canada, Trans.*, sec. 4, vol. 29, 1935.

TAYLOR, T. GRIFFITH, The Archaeocyathinae from the Cambrian of Australia: *Roy. Soc. South Australia, Mem.*, 1910.

VOLOGDIN, A. G., *The Archaeocyathi of Siberia*, vol. 1, 1931; vol. 2, 1932.

WALCOTT, C. D., Cambrian faunas of North America: *U. S. Geol. Survey, Bull.* 30, p. 72, 1886.

A more complete bibliography is given by Okulitch and Vologdin in their respective papers.

## A FOSSILIFEROUS MARINE CLAY NEAR YARMOUTH, MAINE

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and
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The following description of a fossiliferous Pleistocene marine clay near Yarmouth, Maine, has been written in order to record the locality and fauna. In recent years there have been few notes on such occurrences in the State of Maine, and it seems desirable that the knowledge of such localities be preserved.

The clay was found in the summer of 1936 by Whitcomb, who collected fossils from it and sent them to Richards for identification. The exposure is on the shore of Casco Bay, in the Township of Yarmouth, at the head of a cove one-eighth mile northwest of the end of Prince Point, as shown on the Freeport sheet of the U. S. Geological Survey.

A 4- to 6-foot layer of blue-gray clay overlain by glacial till and in places masked by debris from the upper part of the bluff is visible at low tide. The clay contains many rounded nodules of partially lithified clay averaging 1 inch in diameter and ranging up to 2 inches, and the beach is strewn with similar pebble-like pellets. More than 90 percent of the nodules examined contained fossils in the center.

The blue clay matrix contains great quantities of Foraminifera, which Dr. J. A. Cushman has identified as *Elphidium incertum* (Williamson) var. *clavatum* Cushman. The mollusks include: *Buccinum plectrum* Stimpson, a circumboreal species living from the Gulf of St. Lawrence to Greenland and recorded from the Pleistocene of Portland, Maine, and Rivière du Loup, Quebec; *Leda glacialis* Wood, one of the most common fossils of the Pleistocene clays of the St. Lawrence Valley, of Maine, and of the Champlain Valley of Vermont and New York, and living in the Arctic seas; and *Nucula expansa* Reeve, living in the Gulf of St. Lawrence and off the coast of Labrador and known from Pleistocene clays at Portland, Augusta, and Saco, Maine; Duck Cove, St. John, New Brunswick; and Rivière du Loup, Quebec.

A fragment of a crab was identified by Dr. Mary J. Rathbun as *Lithodes* sp., a northern genus for which this appears to be the first record from the Pleistocene.

This fauna is essentially similar to those previously reported from the Pleistocene clays of Maine, the St. Lawrence Valley, and other northern localities, and is probably of late Wisconsin age. The fossils were probably deposited shortly after the retreat of the glacier from the region, while the land was still depressed because of the weight of the ice. The release of this load gradually caused the land to rise, and consequently the sea withdrew, leaving these fossils on raised beaches or terraces.

The fauna from the clays at Yarmouth clearly indicates a cold sea, and therefore fits in with a late Wisconsin dating. The fact that the fossiliferous clay is overlain by glacial till is not necessarily at variance with an assignment to late Wisconsin. At several other places, such as Rivière du Loup and in the James Bay region, these same late glacial clays are overlain by glacial till. The presence of the till over the clay may indicate a slight readvance of the ice or merely the proximity of the glacier to the sea.

## FURTHER NOTES ON THE LICHADACEA

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### MORPHOLOGY

In a recent paper the author discussed the morphology of the Lichadacea (1) and presented evidence indicating that the glabella is composed of six segments, including the occipital segment. The relationship between the peculiar development of the glabellar furrows and the ventral appendages was also inferred on evidence obtained from the dorsal surface of the skeleton. Recently many lichad specimens have been examined in several museums and private collections in England and Scotland, and new facts have been discovered that are of interest in this connection. The writer wishes to express his appreciation to Dr. Murray Macgregor, Mr. F. W. Anderson, Prof. E. B. Bailey, Dr. Ethel D. Currie, Mr. James L. Begg, Prof. O. T. Jones, and Dr. C. J. Stubblefield for permission to study these British collections.

It was previously suggested that the development of the longitudinal glabellar furrows may have been due to a backward migration of the endobases of the coxopodites in the cephalon. As the endobases were modified as gnathites in the cephalic appendages, they must have been intimately associated with the mouth, at or slightly posterior to it in position. Most of the gnathites so far observed in trilobites with appendages are beside or behind the hypostoma. Raymond (2) thinks that the mouth in *Triarthrus*, *Calymene*, and *Ceraurus* was probably in front of the posterior tip of the hypostoma. The mouth must have been either directly anterior to these gnathites or in their midst. Any posterior migration of the mouth must necessarily have taken place along with posterior migration of the gnathites, which otherwise would have become functionless in that capacity. It has been suggested, therefore, that such a movement of the mouth would force the endobases of the coxopodites backwards. This would result in a pulling or stretching in a posterior direction, exerted on the appendifers and muscles in the cephalon, which are attached to the infoldings of the test (glabellar and dorsal furrows). As the mouth is on the median line, this force would be exerted not only posteriorly but also inward toward the axial plane. Thus can be explained the mechanics of forcing the attachments into a line parallel to and inside of the axial furrows, and also the concentration of attachments in a median posterior position in such genera as *Trochurus* and *Euarges*.

If the mouth was just anterior to the posterior tip of the hypostoma in the Lichadacea,

as postulated for *Triarthrus*, *Calymene*, and *Ceraurus*, the hypostoma must have lengthened in the course of the backward migration. It is to be expected, therefore, that the lichad hypostoma should extend nearly or quite to the occipital furrow. At the time when the previous studies were made no lichads with the hypostoma in place had been seen by the writer. Several such specimens in the British collections have since been studied, and it is of interest to record what they show.

The first series of specimens described are in the James L. Begg Collection (Glasgow) from the Ashgillian of Scotland. Numbers BG 2080a, 2080, and 2082 belong to *Platylichas crescenticus* Reed (3).

Specimen BG 2080a has only the complete glabella preserved with the hypostoma in place on the ventral surface. The hypostoma is very large, proportionately, occupying an area slightly greater than the glabella. The main body of the hypostoma extends almost to the occipital furrow, and the border extends well beyond the occipital furrow. It is interesting to observe that the deep furrows separating the main body of the hypostoma from the border are almost directly opposite the axial furrows of the glabella. The hypostoma is articulated directly with the cephalon, no epistoma being present.

Specimens BG 2080 and BG 2082 are the opposite halves of a mold belonging to the same individual. They show features of the inside of the hypostoma together with the doublure of the cephalon in one half, and of the cephalon in the other. The hypostoma in this specimen does not appear to be as long as in specimen BG 2080a but reaches to the occipital furrow. It also appears to be articulated directly with the doublure of the cephalon.

The furrows on the hypostoma are undoubtedly for the connection of muscles for lowering and raising to admit food to the mouth and for holding the hypostoma in place as a protection to the important organs located in the cephalon. The muscles for this function undoubtedly split at some distance on either side of the median line to permit adequate passage to the mouth. That most of the hypostomal muscles in this species were connected with the dorsal furrows is the obvious conclusion from the relationship of the hypostoma and glabella shown in specimen 2080a.

Specimen BG 7630 is a nearly complete *Trochurus geikei*. The glabella has been broken off, showing a mold of the upper surface of the hypostoma, which is very large and extends to the occipital furrow. Similarly, specimens BG 3233, BG 3307, BG 5405, and BG 3303 all show very large hypostomata, each of which extends to or beyond the occipital furrow. In all these specimens the large size of the hypostoma appears to be due to the development of a wide border area.

A remarkable specimen of *Hemiarges scutalis* (Salter) in the Sedgewick Museum (no. A3484) has a very wide hypostoma, which reaches at least to the occipital furrow. In the Geological Museum at South Kensington there is a specimen of *H. scutalis* (no. 19506), which has been cleaned from the ventral surface by Dr. C. J. Stubblefield. In this one also the hypostoma is very long and wide and reaches to the occipital furrow.

In several specimens of *Trochurus anglicus* (Beyrich) in the Sedgewick Museum the anterior furrows show all stages of relative obsolescence, presenting further evidence of the posterior migration of the muscle attachments. Moreover, these specimens clearly show that the basal lobes have become fused with the third lateral lobes and are fundamentally a part of the lateral lobation. A similar condition is seen in specimen no. 2074 in the Museum of Natural History in South Kensington.

Another specimen in the Sedgewick Museum labelled *Lichas anglicus* var. *wenlockensis* (no. A3486) shows a preservation of the complete ventral surface of the dorsal test. The hypostoma is in place and reaches well beyond the occipital furrow. The basal lobes are displaced laterally and are completely outside the border of the hypostoma. This appears to indicate that the basal lobes, which are placed outside the lateral lobes in many genera of the Lichadacea, may have been pushed laterally because of the crowding of a wide hypostoma. These lobes, particularly where defined by deep furrows, undoubtedly indicate concentration of appendage attachments. It is possible that their development may be connected with the appendifers ob-

served under the neck furrow by Raymond (2) or with muscles closely associated with the appendifers.

If the hypostoma was used as the upper lip in trilobites, as seems likely, it functioned as a ventral protection for the mouth and also for the other organs located in the glabellar region. A posterior migration of the mouth should have been accompanied by an increase in size of the hypostoma. It is possible, of course, to argue that the increase in size of the ventral plate in the Lichadacea may have been the sole cause for the peculiar arrangement of the ventral muscle attachments. Inasmuch as the gnathites perform an important function in feeding, however, it is more probable that oral migration was the ultimate causal force and that the hypostoma had a secondary effect or was the immediate cause.

A cause for the oral migration might be sought, possibly, in the development of the fleshy organs located in the glabella. Unfortunately, we know little or nothing about these organs except that the stomach was probably located there. An increase in size of the stomach, in particular, and whatever other organs were in that region may have crowded the mouth into a posterior position. Most lichads possess a swollen glabella, which probably indicates a large size for these glabellar organs. The oral and digestive apparatus comprises organs that are in close relation to the environment and are thus apt to be affected greatly by the feeding habits of the genus or species. The appendages in the cephalon are apt to be subjected to much greater modification than the thoracic ones. Therefore, they are of great value in delimiting groups within families or subfamilies; but their value in general classification may be doubted because of parallelism arising in stocks of different origins but similar habits of feeding. The furrows on the dorsal surface of the glabella are of great value in differentiating groups within subfamilies or families because they indicate variations that have occurred in the cephalic appendages and also, possibly, in the soft organs of the head.

It does not necessarily follow that the ventral rugosities on the test of the glabella were used for attachments for the appendages only. It does appear, however, that since the appendages were subjected to a relatively wide range of movement they must have possessed very strong attachments which varied considerably. It is highly probable that some of the appendage muscle attachments were located at the dorsal furrows.

The above discussion is largely hypothetical, but it has proved a valuable working hypothesis in dealing with the lichadian trilobites and may be of some interest to students of other groups of trilobites.

## A DESCRIPTION OF THE GENUS *Arctinurus*

In the previous paper on the Lichadacea in the Journal of Paleontology (1) the writer inadvertently omitted a description of the genus *Arctinurus*. A description of that genus is here presented. For line drawings consult the previous paper (op. cit., figs. 16, 17).

### Superfamily LICHADACEA Phleger

### Family LICHADIDAE Corda

### Subfamily TETRALICHADINAE Phleger

#### Genus ARCTINURUS Castelnau

*Arctinurus* CASTELNAU, *1843*, Essai Syst. Silur. America, p. 21, pl. 3, fig. 2.
*Platynotus* CONRAD, *1838*, New York Geol. Survey, Rept., pp. 113, 118.
*Oncholichas* SCHMIDT, *1885*, Acad. Imp. Sci. St. Petersburg, Mém., ser. 7, vol. 23, no. 1, p. 31.
*Pterolichas* GÜRICH, *1901*, Neues Jahrb., Beil.-Bd. 14, p. 528.
Genotype: *Paradoxides boltoni* Bigsby, 1825, Acad. Nat. Sci. Philadelphia, Jour., vol. 41, pt. 2, p. 365, pl. 23.

Glabella with quadricomposite lateral lobes; third lateral furrows indicated mesially; longitudinal furrows extending to the occipital furrow, but very weakly developed behind the position of the third lateral furrows; cephalon produced anteriorly in a median tonguelike projection. Pygidium with three pairs of pleurae having free points; axial lobe with two furrows and flaring posteriorly.

REFERENCES

1. PHLEGER, F. B, JR., Lichadian trilobites: *Jour. Paleontology*, vol. 10, no. 7, pp. 593–615, 83 text-figs., 1936.
2. RAYMOND, P. E., The appendages, anatomy, and relationships of trilobites; *Connecticut Acad. Arts and Sci., Mem.*, vol. 7, 1920.
3. REED, F. R. C., The Lower Paleozoic trilobites of Girvan, suppl. 3: *Palaeont. Soc., Mon.*, p. 29, pl. 3, figs. 13–16, 1935.

## ANASPIDA FROM THE LUDLOW OF OESEL

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In his account of Anaspida from the Downtonian of Norway, Kiaer expressed doubt as to the stratigraphic position of the series. He wrote:

> It is doubtless most correct for the present to designate this series, which terminates our Silurian in the Christiania area, as Downtonian, but with the reservation that it may possibly have commenced as early as the uppermost Ludlow.

If the Oesel beds are properly designated as Middle Ludlow there is an interesting correspondence between the ostracoderm fauna and that of Downtonian formations elsewhere. Some distinct genera and families are present—Trematapidae, Oeselaspidae, and Dartmuthiidae, each represented thus far by only one genus, but they are not far removed from Cephalaspidae. *Thyestes* and "*Cephalaspis schrenckii*" are somewhat atypical Cephalaspids, but in the Patten collection at Dartmouth College there are about one hundred specimens that approximate much more closely to the typical Downtonian forms. These have not yet been described, and until they are worked over more thoroughly I cannot be sure whether more than one species is represented. There are also coelolepids in the Oesel material.

The Patten Collection contains a number of fragmentary specimens of Anaspida, a group which has not been reported from Oesel previously. Among them are fragments showing typical anaspid body scales, pectoral spines, and rows of branchial apertures. None show complete heads, a fact that makes it difficult to assign them to families. Since anaspids had not been reported from Oesel formations and since all the European anaspids have been from strata regarded as Downtonian, it has seemed worth while to record this occurrence. The specimens will be described at a later date.

## SOCIETY RECORDS AND ACTIVITIES

## PALEONTOLOGICAL SOCIETY: OBITUARY

### EDGAR STERLING COBBOLD

Edgar Sterling Cobbold, a Correspondent of the Paleontological Society, was born in 1851, and was trained at the University of Manchester as an engineer. After some years at Oxford, where he was engaged in engineering work, he settled in the little town of Church Stretton, in Shropshire, where he served as the city engineer until his death. At Church Stretton he had time and opportunity to follow his real love, which was paleontology, for nearby were Cambrian rocks containing a number of faunas, awaiting study and description. He studied these rocks and their faunas so carefully and thoroughly that he made the region famous and established there one of the best Cambrian sections in the British Isles. For thirty years he delved into the complex geology of Comley and its neighborhood, finding many interesting things that no one had suspected existed there, and he published numerous papers describing them. He had completed the last of the reports on his studies just before his death on November 20, 1936. His publications and collections are a monument to his industry and care.

Dr. Cobbold was one of those modest Englishmen who, though pursuing science as a hobby rather than a profession, have nevertheless added much to the luster of British science. He was one of the most lovable characters whom it has ever been my good fortune to know. Up to the last month of his life he was as full of enthusiasm for his fossils as a boy. He loved the beautiful Shropshire countryside and knew all its antiquities, as well as its natural history. Those men who have had the privilege of tramping over his hills with him will always treasure the memory of the days they spent with him. Such men as he are all too rare. Would that there were more of them in our paleontological fellowship!—*B. F. Howell.*

## ANNOUNCEMENT OF THE SECOND UNIT OF THE ILLUSTRATED CARD CATALOGUE OF NORTH AMERICAN DEVONIAN FOSSILS

The second unit, 9*A*, of the *Illustrated Card Catalogue of North American Devonian Fossils* prepared under the direction of a Committee of the Paleontological Society, will be issued within a month. This unit, prepared by Professor A. S. Warthin, Jr., represents the Ostracoda, and will include all North American species of the Beyrichiacea described up to the end of the year 1936. It comprises 106 cards reproduced in collotype and includes an index card. The compiler has studied about 96 types and topotypes of the species represented. The observations and new figures supply much new and significant information.

The Leperditacea and Cypridacea will be dealt with in a final ostracode unit to be prepared by Professor Warthin at a later date.

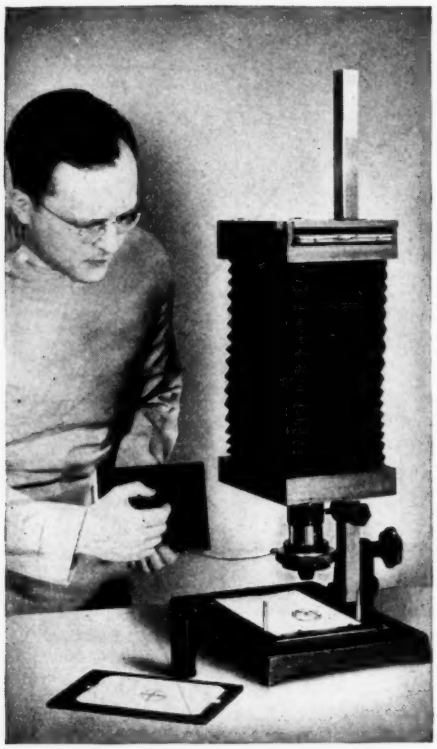
The price of the 106 cards of the Beyrichiacea unit will be $5.50 (plus postage). Since the edition will be limited, orders should be sent promptly to the Wagner Free Institute of Science, Montgomery Avenue and 17th Street, Philadelphia, Pa.

There are still a few sets of the ammonoid unit available at the price of $2.50, plus packing and postage.

## ERRATA

In the explanation of plate 1 of this volume, figures 1 and 2 represent a hypotype of *Hercoglossa merriami* Dickerson, not the holotype.

In the explanation of plate 2 of this volume, figures 10 and 11 represent a hypotype of *Eutrephoceras stephensoni* (Dickerson), not *E. hannai*. Figures 13 and 14 represent the holotype of *Eutrephoceras hannai* Vokes.



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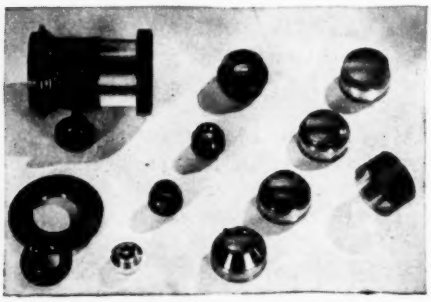

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